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Reducing Vehicle Miles Traveled in Chittenden County Via Modifications to the Built Environment

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REDUCING VEHICLE MILES TRAVELED IN CHITTENDEN COUNTY VIA
MODIFICATIONS TO THE BUILT ENVIRONMENT

A Thesis Presented

by

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to

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of

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ABSTRACT

Vehicle Miles Traveled (“VMT”) is a measure of how much driving a person or a population does in a given period for time. VMT per capita is widely viewed as the strongest correlate of environmental degradation and resource consumption in the transportation sector, a sector that accounts for approximately 1/3 of our greenhouse gas emissions and 1/3 of our overall energy use.

An integrated land use- transportation model was used to simulate the impact that an urban growth boundary would have on VMT over a 40-year modeling horizon in a small metropolitan area, Chittenden County, VT. The results indicate that even in an area with low to moderate population growth, an urban growth boundary has the potential to reduce VMT per person by as much as 25% from a business-as-usual scenario over a 40-year period. The reduction would result primarily from a shift from driving to public transit or walking for many trips. One version of the urban growth boundary would also benefit from shorter average trip lengths.

The obstacles and opportunities for implementation of an urban growth boundary or similar land use regulation are also considered. One pre-requisite for successful implementation of this dramatic change in land use regulation is the existence of a policy champion, who would build support for the idea that ever-increasing VMT should be a concern, and that land use regulations can stem that tide. A second pre-requisite is a new regional-level entity, preferably one endorsed and supported by the state or federal government, to develop boundaries, design restrictions, create incentives, and ensure coordination among the many local entities that would be involved and affected.

TABLE OF CONTENTS

	Page
LIST OF TABLES	v
LIST OF FIGURES	vi
CHAPTER 1: INTRODUCTION	1
1.1. Reasons to Reduce Travel	2
1.2. Potential Solutions	4
CHAPTER 2: LITERATURE REVIEW	7
2.1. The D Variables	7
2.1.1. Defining the D Variables	7
2.1.2. Measuring the D Variables	9
2.1.3. Quantifying the Connection Between the D Variables and Travel	13
2.2. Scenario Analysis	15
2.3. UrbanSim	19
2.4. TransCAD	23
2.5. Implementation Analysis	25
2.5.1. Problem Definition	25
2.5.2. Tractability of the Problem	26
2.5.3. Policy Implementation	28
2.5.4. Policy Tools	34
CHAPTER 3: MODELING THE EFFECTS OF AN URBAN GROWTH BOUNDARY ON VEHICLE TRAVEL IN A SMALL METROPOLITAN AREA	36
3.1. Abstract	36
3.2. Background	36
3.2.1. Connection between the Built Environment and VMT	37
3.2.2. Scenario Analysis	39
3.2.3. Research Gaps	40
3.3. Objective	41

3.4. Methods	42
3.4.1. Study Area	42
3.4.2. UrbanSim/TransCAD	44
3.4.3. Scenario Development	45
3.4.4. Analysis	50
3.5. Results	50
3.5.1. Land Use Results	50
3.5.2. Transportation Results	64
3.5.3. Accessibility Results	66
3.6. Discussion	70
3.6.1. Validation	70
3.6.2. Chittenden County Results	71
3.7. Conclusion	72
3.8 References	74
 CHAPTER 4: POLICY IMPLEMENTATION ANALYSIS: ENACTMENT OF AN URBAN GROWTH BOUNDARY IN VERMONT	 76
4.1. Abstract	76
4.2. Introduction	76
4.3. Problem Definition	79
4.3.1 Current State: Business as usual means increasing miles of travel and converting increasing amounts of open space for development	79
4.3.2. Causal Statements: The connection between land use and transportation	81
4.3.3. Examples from other regions	83
4.3.4. Desired Outcome: What do we want to achieve?	85
4.4. Policy Formulation	86
4.4.1. Key actors: Towns and NGOs must instigate and implement policy change	86
4.4.2. Governance structure: A new regional entity	90
4.5. Policy Implementation: Moving from concept to action	95
4.6. Policy Evaluation	101

4.7. Conclusion	103
4.8. References	104
COMPREHENSIVE BIBLIOGRAPHY	108

LIST OF TABLES

Table	Page
Table 1: Scenario summary	47
Table 2: Growth in residential units by town	54
Table 3: Areas with varying levels of residential density	59
Table 4: Land use mix	64
Table 5: Transportation results	65

LIST OF FIGURES

Figure	Page
Figure 1: Study area	43
Figure 2: Borders of growth areas in (a) urban core scenario and (b) multi center scenario. Shading indicates residential density as of 1990	48
Figure 3: (a) Total residential density in 2030 under the business-as-usual scenario, and (b) residential unit growth from 1990 to 2030 under the same scenario	52
Figure 4: Residential units per gridcell in 2030 in (a) urban core scenario and (b) multi center scenario	56
Figure 5: Commercial and industrial square feet per gridcell in (a) 1990; (b) 2030 under the business-as-usual scenario; (c) 2030 under the urban core scenario; and (d) 2030 under the multi center scenario	60
Figure 6: Difference in accessibility logsums in 2030 between the business-as-usual scenario and the urban core scenario. TAZs beyond the extent of Figure 6 had no meaningful difference in accessibility between the scenarios	68

CHAPTER 1: INTRODUCTION

Since the dawn of the automobile age, Americans have driven more and more every year. In 1940, people drove an average of 2,300 miles per year. By 1980, the annual average was up to 6,700 miles per year, and by 2008 the average had soared to 9,800 miles per year (Federal Highway Administration, 2010). Because population has been growing over this time period as well, the total amount of vehicle miles traveled, or VMT, has grown even faster. By 2010, Americans were driving a total of 2.97 trillion miles in a year (Federal Highway Administration, 2010). The national figures mask a large range. In the New York metropolitan area, for example, a densely populated city with good public transportation, the annual average in 2005 was less than 6,000 VMT per person. By contrast, the annual rate in a city like Jacksonville, Florida is more than 13,000 VMT per person (Brookings Institute, 2008).

Even within those regional estimates there is significant variation among residents of different neighborhoods. New Yorkers who live in Manhattan drive, on average, less than 3,000 miles per year, residents of Westchester County drive an average of 9,885 miles per year, and residents of Suffolk County in Long Island drive more than 13,700 miles per year (New York State Dept. of Env. Cons., 2011). Despite all of this variability, VMT is a useful measure of the overall travel patterns of an individual, a region, or a country.

Vermont's statewide average is over the national average, with 11,680 VMT per person, probably because so much of the state is rural. By contrast, Chittenden County,

the most urbanized part of the state, is slightly below the national average, at 9,855 VMT per person (Sears & Glitman, 2010).

As researchers Robert Cervero and Jim Murakami have stated, “VMT per capita is widely viewed as the strongest single correlate of environmental degradation and resource consumption in the transport sector – as individuals log more and more miles in motorized vehicles, the amount of local pollution (eg particulate matter) and global pollution (eg greenhouse gas, or GHG, emissions) increases, as does the consumption of fossil fuels, open space, and other increasingly scarce resources.” (Cervero & Murakami, 2010).

VMT is not the only travel measure of interest. Vehicle trips is another important measure. Very short trips may not have much impact on the total VMT of a population, but short trips tend to be more emissions intense and less fuel efficient, so they can have a significant effect on environmental quality. Another relevant measure is time spent traveling, or vehicle hours of travel (“VHT”), which can have significant effects on quality of life. This paper will focus primarily on VMT, but will make reference to other travel measures when appropriate.

1.1. Reasons to reduce travel

There are significant financial, environmental, and social costs associated with all of that driving. On average, American households devote 16% of their total annual expenditures to transportation, more than they spend on food, clothing, healthcare, or entertainment (Bureau of Labor Statistics, 2009). The transportation sector was

responsible for 28% of green house gas emissions in the United States in the year 2008 (US Dept. of Energy, 2010). It was also responsible for 73% of carbon monoxide emissions, 58% of nitrogen oxide emissions, and 38% of volatile organic compounds emissions (US Dept. of Energy, 2010). Most researchers agree that improving fuel efficiency and reducing emissions will not suffice to solve the challenges caused by our transportation demand -- we need to reduce VMT as well (Cervero & Murakami, 2010).

Similarly, the transportation sector was responsible for 29% of energy use in the United States in the year 2008 (US Dept. of Energy, 2010). Most of the energy used for transportation is petroleum-based (93.8% in 2009, 2.5% natural gas, 3.4% renewable, 0.3% electricity) (US Dept. of Energy, 2010). The fossil fuels that power our transportation system are a limited resource. US oil production peaked in 1970 (Grubb, 2011). There is an ongoing debate on whether global oil production has already peaked, or on when it will peak, but World Energy Outlook 2010 predicts that the peak may come as soon as 2035. They note, moreover, that demand for oil appears to be increasing faster than supply (although the rate at which supply develops is greatly affected by demand, because oil producers need to determine when and whether it's worth exploring and investing in new fields) (International Energy Agency, 2010). In any event, increasing cost and decreasing supplies of fossil fuels are yet another reason to work towards reducing VMT.

Other research suggests that reducing VMT may be essential if we want to avoid the need to build massive new road infrastructure and/or endure ever worsening road congestion. Average travel speeds are declining which indicates that congestion is on the

rise (Polzin, 2006). From 1982 to 2009, yearly hours of delay have increased in cities of all sizes. In the largest cities, residents had an average of 19 hours of delay per year in 1982, compared to 50 hours of delay per year in 2009. In smaller cities the figure has gone from 5 hours of delay per year in 1982 up to 18 in 2009 (Texas Transportation Institute, 2010). These changes suggest that existing roads in cities of all sizes are hitting capacity limits.

The reasons for reducing VMT are not only linked to technical issues about emissions, fuel use, and roads. Researchers in California, looking at data on a county-by-county level, have found a correlation between the prevalence of obesity and VMT per capita (Lopez-Zetina, Lee, & Friis, 2006). While there is no scientific proof of a causal link, common sense indicates that getting out of the car and choosing to walk or bike to some destinations would reduce VMT and would also be part of a healthier lifestyle.

1.2. Potential Solutions

There are many potential mechanisms for reducing VMT. Many of the problems identified above might be addressed with technical advances and innovation. For example, improved vehicles can get better fuel efficiency, emit less pollution, and even maneuver more safely at high speeds on congested roads. In general, electric cars are more efficient than gas-powered vehicles, and emit less pollution. However, the process of developing a robust market in electric vehicles will take decades, as will developing the electrical grid infrastructure to support those vehicles. As of 2008, there were 57,000 electric vehicles on the road out of 256 million vehicles total in the United States (Bureau

of Transp. Statistics, 2010; Davis, Diegel, & Boundy, 2010). Even if demand for such vehicles were to rise dramatically, availability will remain limited in the present and near future (International Energy Agency, 2009).

Some have suggested that promoting telecommuting could reduce VMT. Trips to and from work typically make up 20% of our average VMTs (Federal Highway Administration, 2009). If people are allowed to work from home, instead of commuting to their job, there is an expectation that there would be fewer cars on the road. However, studies seem to indicate that telecommuting effects are limited. As of 2004, only 1-2% of the US workforce was telecommuting on any given day (P. Nelson, Safirova, & Walls, 2007). There are several reasons that all may contribute to the limited success of telecommuting in reducing VMT. Only certain categories of jobs are well-suited to telecommuting. Many manufacturing, service, and even professional jobs require that workers be physically present in a certain place at a certain time. In addition, not all workers who are eligible for telecommuting find it desirable. Most people whose jobs are well-suited to telecommuting and who choose to telecommute do it only once a week or so. Finally, it appears that many people who save on trip-to-work time by telecommuting one or more days per week appear to spend that time engaging in other travel for other purposes (Mokhtarian, 1998).

A third set of potential solutions involves making driving more expensive. A substantial body of research and experience supports the idea that significant reductions in VMT would result from a variety of mechanisms that make driving (and especially driving in single occupant vehicles) more expensive, such as highway tolls, cordon

pricing, congestion pricing, carbon taxes, fuel taxes, VMT taxes, and parking charges. However, these policies raise significant concerns about social equity and impact on the health of the economy. There are also significant questions about the political feasibility of many of these solutions. In any event, much of the research that supports these proposals indicates that they would be even more effective if implemented in conjunction with changes in land use policy and regulation. In that way, future development would be more likely to occur in a way that makes it easier for people to limit their driving while still having access to the places they need to go (Cambridge Systematics, 2009).

My research is focused on a fourth type of solution. The solution considered here relates to modifying the built environment, over time, to bring people and jobs closer together. The idea is to have people living and working in spaces that make walking, biking, and public transit feasible and enticing, so that people naturally choose to drive less.

CHAPTER 2: LITERATURE REVIEW

2.1. The D Variables

According to some research, compact development, which is a particular form of built environment, has the potential to reduce VMT per capita by 20 to 40 percent relative to sprawl, another type of built environment (Ewing, Bartholomew, Winkelman, Walters, & Chen, 2007). This simple statistic glosses over a lot of important detail and many as-yet unanswered questions. For purposes of the present project, the most important questions are how to describe and quantify the built environment, moving beyond a single dichotomy of “compact development” and “sprawl,” and how to accurately measure the connection, if there is one, between different forms of built environment and various travel measures, including but not limited to VMT.

2.1.1. Defining the D variables

Most research and discussion about the link between the built environment and travel measures focuses on certain attributes of the built environment that are collectively referred to as “the D variables.” The D variables are measures of various aspects of the built environment that are believed to affect people’s need or desire to travel and their choice of mode for travel (private vehicle, walking, public transit, etc.). The phrase appears to have been coined about 15 years ago by Robert Cervero, who used the phrase “the Three Ds” to capture three elements of the built environment that were understood to be relevant to vehicle miles traveled and other measures of travel behavior: density, diversity, and design (Cervero & Kockelman, 1997).

Of the three original D's, the one that has received the most attention is density. The assumption is that when the built environment is more dense, i.e., when there are more people living in close proximity to each other, there is less need to travel. Similarly, when the built environment is more diverse, meaning that homes, stores, and jobs are mixed together, rather than being isolated in separate zones, there is less need to travel. Finally, the design of the environment, including such things as the presence or absence of sidewalks and the average block size will affect people's decisions of how to travel (whether to drive or walk), and thus will affect measures of driving behavior (Cervero & Kockelman, 1997).

Over time the list of D variables has expanded. Current versions may also include includes degree of centering, a measure of the overall layout of a city – not just how dense it is at its core, but also how the density decreases as one moves away from the core and towards the periphery. Destination accessibility measures how many jobs, shopping outlets, or other destinations are within a set travel time. Distance to transit is measured from residential or work locations to the nearest bus stop or rail station (Ewing, et al., 2007). Lastly, demand management refers to policies, systems, or structures that are intended to reduce the demand for driving private vehicles by making it more difficult or expensive to drive, such as limiting or eliminating free parking in certain areas (Cambridge Systematics, 2009). The D variables continue to dominate the thinking about the relationship between the built environment, VMT, and other travel behaviors.

2.1.2. Measuring the D Variables

One of the major challenges in researching the interplay between the D variables and travel measures has been developing adequate ways to operationalize the variables. A 2003 paper by Reid Ewing, Rolf Pendall and Don Chen set a new standard for capturing the complexity subsumed in several of the D variables. In this paper the authors set forth a new series of built environment descriptors (called “sprawl indicators”) to measure the connection between built environment and travel behavior. They were motivated in part by the observation that earlier studies had large disparities in conclusions, and that these disparities seemed to be driven by differences in how the built environment was being measured (Ewing, Pendall, & Chen, 2003)

In examining density, for example, they identified seven distinct measures that all capture different aspects of residential density: (1) the number of people per square mile (excluding any census tracts within the region with fewer than 100 people per square mile); (2) the percent of the population living at low suburban density (fewer than 1500 people per square mile); (3) the percent of the population living in high density (more than 12,500 people per sq. mile); (4) the density at the center of the metropolitan region; (5) the density of urban lands in the metropolitan region; (6) the average lot size for single-family dwellings; and (7) the density of all population centers in the metro region. (Ewing, et al., 2003). For diversity they measured (1) the percent of residents with businesses within ½ block of their home; (2) the percent of residents who live within 1 mile of shopping opportunities; (3) the percent of residents who live within 1 mile of a public elementary school; (4) the balance of jobs and residents for each Traffic Analysis

Zone (TAZ) compared to the region as a whole; (5) the balance of retail jobs for each TAZ as compared to the region as a whole; and (6) the mix of jobs by TAZ (Ewing, et al., 2003). For design, they focused on street accessibility, measuring (1) average block length; (2) average block size; and (3) the percent of small blocks (less than 0.01 square miles) (Ewing, et al., 2003). For centering they measured (1) variation in tract density; (2) density gradient; (3) % of employment within 3 miles of center; and (4) the percent of employment located more than 10 miles from center (Ewing, et al., 2003).

After measuring each of these variables for the 83 urban regions in their study, they used principal components analysis to create a single measure for each of the four D variables. The value of applying principal components analysis in this type of study is that it enabled the researchers to discuss their results in familiar terms – “diversity is more important than density,” or vice versa. The weakness is that much of the fine grain detail that went into the many measured values is lost when the data is summarized with a single figure.

This particular study also refined the measurement of travel behavior, using several different dependent variables: (1) average number of vehicles per household, (2) percent of commuters using public transportation; (3) percent of commuters walking to work, (4) mean journey-to-work time in minutes, (5) annual hours of travel delay per capita; (6) daily VMT per capita; (7) annual highway fatalities per capita; (8) fourth highest daily maximum 8-hour average ozone level (Ewing, et al., 2003). These were not combined into a principal components analysis, but were each treated separately. The study also included control variables, including (1) metropolitan area population; (2)

average household size; (3) percent of population that is working age (between 20 and 64); and (4) per capita income (Ewing, et al., 2003).

In evaluating data from 2000, the researchers found that the composite density factor had the strongest relationship to several of the dependent variables, including VMT per capita, vehicles per household, public transit use, walking, highway fatalities, and ozone levels (Ewing, et al., 2003). Further, they found that none of the other built environment variables (diversity, centeredness, or design) had a statistically significant impact on VMT per capita. Centeredness was the second strongest factor, although not statistically significant on VMT (Ewing, et al., 2003). However, when they applied the same study methods to data from 1990, they came up with surprisingly different results. With this data, centeredness was the most significant composite factor overall, and the only statistically significant factor for VMT. Both years, the researchers noted the salience of various control variables, particularly auto ownership rates and household size (Ewing, et al., 2003).

There are many possible explanations for the differences in outcome between the 1990 data and the 2000 data. It may be that the relationship between the variables and outcomes being examined is not fixed, and that it varies over time. It may be that the principal components analysis sacrificed too much detail, or that the measurements of the D variables were in other ways imprecise. The authors of the study note that much of the data they were using was highly aggregate, and that it came from multiple sources that were not always consistent across geographical areas or time periods (Ewing, Penall et al. 2003). And, it may be that there are other important factors influencing the travel

outcomes that were not captured by their model, such as economic activity or conditions or demographics.

Others have addressed the question of how to better measure various of the D variables. Despite the quantity of measurements that went into Ewing and Pendall's analysis of density, there may have been imprecision or excessive aggregation in the data. There can be a significant difference between gross density (using total land area, including parking lots, roads, etc.) and net density (using only residential acre as the denominator) (Krizek, 2003). There are also significant differences in density measurements depending on how large an area is covered by the measurement. Many urban areas have small pockets of very dense population, surrounded by larger areas with lower density. Averaging the entire area does not capture the high density core or the lower density outskirts. In addition, the borders used to delineate separate units of analysis, typically census block groups or tracts, or traffic analysis zones, will often divide dense neighborhoods in half by using main thoroughfares as borders (Hess, Moudon, & Logsdon, 2001).

To improve precision in measuring land use diversity, it is important to bear in mind that certain types of commercial establishments are the most desirable in a residential neighborhood: drug store, food market, gas station, post office, specialty food, and bank (Krizek, 2003). Ewing, Pendall and Chen distinguished between shopping, schools, and jobs, but did not get to the finer level of detail reflected in Krizek's different types of shopping opportunities.

For design, Krizek and others have recognized the importance of measuring both street patterns, such as number of 4-way intersections and block length, and also pedestrian amenities, such as sidewalks, street width, pedestrian crossings, and street trees (Ewing, et al., 2007; Krizek, 2003). However, these variables are generally harder to gather data on and operationalize, and many studies continue to omit them even when they recognize their theoretical importance.

2.1.3. Quantifying the Connection Between the D Variables and Travel

Early studies of the connection between the built environment and travel outcomes found significant inverse effects between density and VMT (Newman & Kenworthy, 1999). However, that early simple conclusion has been criticized on several grounds. It involved highly aggregate data, which may have introduced the imprecisions described above. Also, the aggregate data indicated correlations between density and VMT on a city-by-city basis, but said nothing about the behaviors of individuals within those cities, or even about the patterns neighborhood-by-neighborhood. Many researchers have expressed concerns about self-selection effects, in which correlation between density is an artifact of joint preferences for dense and diverse neighborhoods and minimizing auto use, as opposed to minimizing auto use being a result of dense neighborhoods (Cao, Mokhtarian, & Handy, 2009).

Over the last decade researchers have attempted to clarify the connection between the D variables and travel outcomes, both to quantify it and to establish causation, not just correlation, by controlling for self-selection effects, among other things. Results are typically reported in terms of elasticity of travel behavior to different built environment

characteristics. For example, a recent study that used structural equation modeling on data from 370 urbanized area concluded that the direct elasticity between population density and VMT per capita is -0.6, meaning that a 10% increase in population is associated with a 6% decrease in VMT per capita. However, that relatively strong direct effect was partially offset by positive indirect effects. For example, areas with higher population density also tend to have higher road density, and higher road density is correlated with higher VMT/capita. A similar positive indirect effect was found for the higher retail accessibility and greater urbanized area sizes of more densely populated areas. Taking the direct and indirect effects into account, the net effect of a 10% increase in population density is only a 3.8% decrease in VMT per capita (Cervero & Murakami, 2010).

Other studies have found smaller effects. One recent study of data from 7666 California households concluded that a 10% increase in residential density was correlated with a decrease in VMT of 1.9% (Heres-Del-Valle & Niemeier, 2011). A meta-analysis of the data from 50 studies found an even smaller elasticity. In this study, VMT was most sensitive to distance to downtown (also called destination accessibility), with a weighted average elasticity of -0.22, and job accessibility by automobile, with a weighted average elasticity of -0.2. This means that a 10% increase in destination accessibility was correlated with a 2.2% decrease in VMT. The next most important variables were intersection/street density and percent four-way intersections, both of which had weighted average elasticities of -0.12. Surprisingly, given the results of earlier work, these researchers found little sensitivity of travel behavior -- not just VMT, but also

walking trips and transit use -- to density. The range of elasticities of VMT to density across the underlying studies was -1.05 to +0.03, and the weighted average elasticity was -0.04 (Ewing & Cervero, 2010).

Despite the work that has been done to clarify how to measure the various aspects of the built environment that are expected to affect VMT, studies still have widely varying results. Part of the problem is that overall effects are small, and other factors, such as household income and employment status may dwarf the effect of the built environment on travel behavior. Although it is possible to control for these variables, a lot of detail is lost in the process of controlling, and significant distortions may affect the results. Some researchers have found that attitudinal and lifestyle variables are more important in determining travel behavior than built environment characteristics are (Bagley & Mokhtarian, 2002). Another significant problem is the limitations of the available data, and in particular the lack of longitudinal data, which could clarify the difference between correlation and causation, as well as the inherent difficulty of establishing causation in any complex system. Nonetheless, it seems clear that the built environment affects how much people drive; from that, we can conclude that changing the built environment will likely lead to changes in how much driving people do.

2.2. Scenario Analysis

The studies described thus far attempts to quantify the connection between existing land use and existing travel patterns. This information can be used to predict

how changing land use may affect travel outcomes, but it is not, technically speaking, a prediction.

A different type of study, generally referred to as scenario analysis, attempts to predict the effect that a change in land use will have on future travel patterns.

Simulation studies “assume certain relationships between urban form and travel patterns and then use these assumed relationships to predict the implications for travel of alternative forms of development” (Handy, 1996). This method of analysis is called scenario studies because the researcher uses different land use scenarios to model how changing the land use will change the travel patterns. A scenario is “an internally consistent view of what the future might turn out to be – not a forecast, but one possible future outcome” (Bartholomew, 2007).

Scenario analysis is performed occasionally by academics, but more often this means of study is performed by metropolitan planning organizations (“MPOs”) or other regional entities and non-governmental organizations (“NGOs”) (Bartholomew, 2007). Planners and NGOs using scenario planning often have an agenda: they want to convince the public that a certain scenario is better or worse than another (Bartholomew, 2007). Any scenario analysis results should be evaluated with the potential for bias kept firmly in mind.

Scenario analysis is often not very sophisticated. In one broad survey of land use and transportation scenario analyses, only 47 of the 80 scenario analyses identified for the study made use of a computerized travel model. Of those, only seven had a land use model as well (Bartholomew, 2007).

The variables most often studied in scenario analysis include the location of growth, the density of growth, land use diversity, and transportation system elements (Bartholomew, 2007).

As with the studies of the D variables and VMT, scenario studies also typically report more detail on density than on other built environment attributes. Using that data, a meta-analysis of 23 scenario studies found a linear relationship between density and VMT across the studies, under which a 10% increase in density would lead to a 5% reduction in VMT and a 50% increase in density would lead to a 16% reduction in VMT (Bartholomew & Ewing, 2009). Other statistically significant variables in the meta-analysis included whether or not the scenario included infill or compact development and whether or not it promoted mixed land use. The observed effect of encouraging mixed land use was almost three times as strong as the effect of infill development. Variables reflecting whether or not the scenario provided for coordinated transportation investment, demand management, and centeredness were not statistically significant (Bartholomew & Ewing, 2009).

Other meta-analyses of scenario studies have reached similar conclusions. An analysis of results from 22 scenario studies found that land use changes alone led to predicted decreases in VMT with a median of 0.5% at 10 years, and 1.7% at 40 years (Rodier, 2009). The largest observed effects on VMT for a single strategy came from a VMT tax or fuel tax. Both of these strategies led to predictions of VMT reductions of about 10%. The largest overall effect on VMT over the 40-year time horizon was for combined strategies that included land use changes, tax strategies, and transit policies,

such as increased the frequency of transit service. The combined strategy yielded a prediction of a 24.1% reduction in VMT over 40-year scenario (Rodier, 2009).

Another meta-analysis of scenario studies that found that a decrease in VMT of 18% could be predicted over a 43 year time frame if density increased by 50% (Ewing, et al., 2007). By contrast, Driving and the Built Environment reported a likely range of potential reduction in VMT of 1% to 11% over 40 years resulting from more compact, mixed-use development. They found that doubling residential density across a metropolitan area might lower household VMT by only 5 to 12% (perhaps by as much as 25% if it were coupled with higher employment concentrations, significant public transit improvements, mixed uses, and other supportive demand management measures) (Transportation Research Board, 2009). The most important differences driving the differing results of these two studies were the assumptions about growth rates and the rate of replacement of existing land uses.

There are many ways that scenario studies could be improved. In addition to incorporating travel models and land use models (and especially integrated models that combine both), they could use smaller traffic analysis zones and better measures of land use diversity. Other avenues for improving scenario analysis would be modeling trip chaining behavior (where the trip home from work is combined with a trip to the grocery store, for example, rather than treating those as two separate trips), as well as greater attention to walking and bicycling trips, and great attention to design (Bartholomew & Ewing, 2009).

2.3. UrbanSim

Although the connection between transportation accessibility and real estate development has long been known, until recently land use and transportation systems were modeled separately, with no way to capture feedback effects between the two systems (Waddell, Ulfarsson, Franklin, & Lobb, 2007). Modeling of transportation projects has been required as a condition of federal transportation funding since the 1960s, but the focus of that modeling effort was primarily on interstate highways, not on local travel or land use (Weiner, 1992). Integrated land use and transportation models began to be developed years ago, but they typically relied on static equilibrium modeling, they often did not reflect market dynamics, and they generally operated at a highly aggregate level, using large areas as the basis of analysis (Iancono, Levinson, & El-Geneidy, 2008). It was also difficult to implement those earlier models in a given area because of the data demands inherent in reflecting a region's transportation network and demand in a new model framework. UrbanSim is a land use allocation model that was developed to remedy that situation, by being designed so that it could be integrated with any of a number of different travel models, often as already in use in a given region (Hunt, Kriger, & Miller, 2005).

UrbanSim takes as inputs existing land use, including whether each parcel of land in the area being modeled has been developed for residential, commercial, or industrial use, or whether it is vacant. It also takes as inputs existing zoning restrictions and other factors related to suitability for development, including the slope of the land, any

wetlands, whether the land is served by existing sewer service, and the distance to various amenities like a central shopping or business district, schools, or parks (Waddell, 2002).

The land use data is entered into a database on the basis of “gridcells” of a user-defined size that overlay the entire geographic region. The model as developed for Chittenden County uses 150m x 150m gridcells. Each gridcell thus has an area of approximately 5.6 acres. There are approximately 64,000 of them for Chittenden County. The land use data is aggregated or averaged by gridcell (Voigt, Troy, Miles, & Reiss, 2009; Waddell, 2002).

UrbanSim also requires demographic data, including the number of persons living in an area, the number of workers, the number of children, and household income ranges. UrbanSim uses the socioeconomic data, typically provided at the census block group level, to generate synthesized households to populate each gridcell. The synthesized households match the block group data as a whole for the number of households, household sizes, number of workers, and household income. These synthesized households then become agents within the model, which operates at a disaggregate level, in which each household makes decisions such as whether or not to move, and where to move to, based on the household’s synthesized socioeconomic characteristics.

UrbanSim also requires commercial data, such as the number of jobs in the area and what employment sector they are in, which are also apportioned to gridcells. Finally, UrbanSim takes as input population and employment forecasts for the region. This information is exogenous to the model, remains at the regional level (not gridcells), and is not affected by the model results (Waddell, 2002).

Although often referred to as a model, UrbanSim is actually a series of submodels that are integrated with each other. Each sub-model simulates the key decisions to be made by the agents in the submodels: households, employers, and real estate developers (Waddell, 2002). The submodels are primarily discrete choice binomial or multinomial logit models that model choices between a finite number of mutually exclusive options, such as whether a household will move or not move in a given model year, and then, if they are moving, which of the available properties on the market they will choose to move into, based on a stochastic decision making process where the characteristics of each available property determine the probability that a given household will select that property over other available properties (Ben-Akiva & Lerman, 1985).

UrbanSim is tailored for each place it is implemented. In addition to developing and inputting the data for the gridcells database, tailoring includes selecting which submodels will be used and estimating coefficients for each submodel based on the local data (Patterson 2010). The selection of submodels and particular variables to include in each submodel is based on what data is available, as well as on the results of statistical model estimation (Patterson 2010). By estimating the models based on actual data each implementation of the model is customized for the place in which it is being used. This allows researchers working with UrbanSim to develop versions of the model that best fit the data for their location, and also that best fit the research questions of interest to the modelers.

The commercial and industrial location choice submodels are rooted in economic theory on firm location, including competitive bidding for sites with better accessibility,

agglomeration economies, and the effects of transportation costs and government policies on firm location choice decisions (Waddell, et al., 2007). The residential location choice submodel is based on the trade-off between transportation and land cost, access to amenities and qualities of the existing built environment (Waddell, et al., 2007). The real estate development submodel interacts with the employment and household location choice models, as well as the land price model. In this model, theory says that developers should be motivated by profit, and constrained by resources, physical environment, and land use regulations. The decisions to be modeled include whether to develop, where to develop, and the quantity of space to develop. The land price submodel is a regression model, which uses hedonic pricing theory, in which the price for a property is broken down into component parts, each of which is valued and then summed together (Waddell, 2002). The land price model is calibrated from historic data, and it includes the effects of the, the neighborhood, accessibility, policies, and vacancy rates (Waddell, 2002).

Many advantages of UrbanSim over earlier integrated land use-transportation models have been identified. Chief among them is that UrbanSim operates in dynamic disequilibrium, which makes the market modeling more realistic than a model in which supply and demand are artificially forced to equal out every year (Hunt, et al., 2005). Also, UrbanSim endogenizes demographic transitions based on the baseline demographic data (Hunt, et al., 2005). This, again, allows the model to more realistically mirror reality. The level of disaggregate analysis in the land use model, along with the relatively

small zones in the travel model, are also an improvement over many other integrated models (Hunt, et al., 2005; Waddell, et al., 2007).

2.4. TransCAD

UrbanSim as implemented for Chittenden County has been integrated with Chittenden County's Travel Demand Model, which was developed using TransCAD v.4.9 (Caliper Corporation). (Voigt, et al., 2009). The travel demand model is a four-step model, based on a road network that covers the entire county and 335 traffic analysis zones (TAZs) delineated within the county plus 17 external TAZs to reflect traffic entering and/or leaving the county on major roads (Resource Systems Group, 2008). Small regions, with population less than 200,000, typically have about 280 TAZs, with a density of about 0.9 TAZs per square mile. (Transportation Research Board, 2007). Chittenden County thus has smaller TAZs than typical for a region of its size, which will yield better results from the modeling effort.

The travel demand model begins with the first step of trip generation, in which the model determines how many trips will originate and terminate in each zone for various purposes. This estimation depends on the land use within each zone, whether it has residential, commercial, or other occupants, as well as the demographics of each zone, including the population, income, employment status, vehicle ownership rates, and so on (Transportation Research Board, 2007).

The second step in the travel demand model is trip distribution, in which the model combines the trip origins with trip destinations based on a "gravity model," in

which number of trips between any pair of zones is determined by the number of trips from and to each of the zones as well as the ease or difficulty of traveling from one zone to the other, based on the road network, congestion, and other factors like tolls or other costs. (Transportation Research Board, 2007).

The third step in the travel demand model is mode split, where the model determines how many of the trips will occur by each of the possible travel modes, in this case drive alone, shared ride, transit, or walk/bike. Mode split is determined based on trip purpose, origin and destination, and ease and cost of using each mode. (Transportation Research Board, 2007). Finally, the trip assignment step puts the modeled trips onto specific routes on the road network, and the model evaluates the impact of the trips on congestion rates on the network. The model repeatedly iterates trip distribution , mode split, and trip assignment until a stable solution is reached (Transportation Research Board, 2007).

Four-step models were designed primarily for planning major highway systems. They have been criticized as inappropriate for smaller-scale land use or transportation planning, because of insensitivity to land use changes, and because of lack of trip chaining (Transportation Research Board, 2007).

In the integration of the travel demand model with UrbanSim, the land use portion of the model runs for every year of the simulation. Once every five years, a python script passes the land use data to the travel model. The land use data that is relevant to the travel model includes the number and attributes of households in each TAZ as well as the number and attributes of employers in each TAZ (Resource Systems Group, 2008). After

the travel model runs, the updated accessibility of each TAZ is passed back to UrbanSim, and becomes part of the land use decision-making process for each future year of the simulation, as covariates in certain of the discrete choice submodels (Voigt, et al., 2009).

2.5. Implementation Analysis

2.5.1. Problem Definition

The essential first step in any policy implementation analysis is defining the policy problem. Defining a policy problem is essentially an empirical issue, but the data will often be tempered and filtered by political considerations. The way a problem is defined will draw attention to some aspects of the problem and minimize others. It can change the profile of the problem or the public's attitude towards the problem. It can also shape the range of proposed solutions and how the public views them (Layzer, 2002).

A good problem definition should begin with a description of the facts that are at the core of the current state and the problem. These facts should not be controversial. The problem definition should also include an assessment of the causal relationships between key components of the policy system. There is often a range of uncertainty associated with the causal relationships. This uncertainty must be acknowledged, but the goal should be to draw the strongest assessments we can from the available data (Layzer, 2002). Finally, the problem definition should include a set of beliefs about how the system ought to work and an assessment of nature of changed behavior desired (McDonnell & Elmore, 1987).

2.5.2. Tractability of the problem

Another lens through which to view a policy problem definition is to evaluate the tractability of the problem. There are many factors that determine the tractability of a problem. Problems are more tractable if the causal link between the problem and the fix is clear. Problems are also more tractable if the behavior that we want to change or proscribe falls into a limited range, the number of actors whose behavior must change is relatively small, and the extent of behavioral change needed is not great (Mazmanian & Sabatier, 1981).

Reducing VMT appears, at first, to be an intractable problem. The growth of VMT over the century since the invention of the automobile is associated with a wide array of other changes, including the increase in disposable income, the increased participated in the workforce, especially by women, as well as sprawling residential development (Polzin, 2006). These factors all contribute to the problem, and are part of the reason that it is so difficult to pin down a precise relationship between the built environment and VMT. The complexity and breadth of these factors and the way that they relate to the growth of VMT obscures any vision of an easy solution.

The problem also appears intractable because it related to such a common, widespread, and even treasured behavior – driving. Almost 90% of the adult population had a driver's license in 2008, up from only 57% in 1950 (Federal Highway Administration, 2010). That makes it seem as though reducing VMT requires changing the behavior of nearly everyone in our society – clearly an intractable situation.

However, if we view this apparently intractable problem through the lens of a proposed

solution – specifically an urban growth boundary – it becomes, while not quite tame, at least somewhat more tractable.

An urban growth boundary (“UGB”) is an attempt to make the VMT problem more tractable. A UGB is a zoning or land use provision that redirects the real estate development activity in an area away from the open spaces in the periphery and back towards the urban core of the region. It does so by delineating two concentric regions. The inner region is the core, within which most or all new development should occur. The outer region, which forms a rough doughnut shape around the inner core, is the area in which new development is discouraged or forbidden. Beyond the outer region no new restrictions are imposed, usually because the area outside the second line is beyond the authority of the entity enacting the UGB.

Rather than attempting to influence the behavior of everyone who gets into a car and turns the ignition, a UGB would directly affect the behavior only of the small proportion of the population that plans to build new residential or commercial structures in the doughnut-shaped area where such development has been restricted. Of course, there are indirect effects on much of the rest of the population, because the new rules about real estate development will affect where there are new properties available to buy or rent, it will affect the density and mix of properties inside the boundary as the area continues to develop, and it may affect property values throughout the region. However, so long as there continues to be sufficient growth to satisfy demand for housing and commercial space, these indirect effects should not be severe (Jun, 2004; A. Nelson, Dawkins, & Sanchez, 2007).

By changing where developers are allowed to build new houses and new commercial and industrial spaces, the UGB in effect creates a technical solution to a problem that at first blush did not appear to have one. If the causal statements about the relationship between the built environment and VMT are correct, the change in VMT should follow. The remaining uncertainty about the strength and magnitude of that causal relationship is thus the remaining element of intractability. If the research that finds a strong relationship between the built environment and VMT is correct, then the proposed solution has converted an intractable problem into one that is relatively manageable.

2.5.3. Policy Implementation

Over the past few decades, as government policies and programs have proliferated and the role of democratic government has continually grown, analysts have begun to think ever more deeply about the mechanisms for implementing policy decisions: what tools are effective, who are the key players, what type of situations derail well-intended policies (Brinkerhoff & Crosby, 2001; Elmore, 1979; Layzer, 2002; Mazmanian & Sabatier, 1981; McDonnell & Elmore, 1987; Nakamura & Smallwood, 1980). In considering the viability of reducing vehicle miles traveled (VMT) by modifying the built environment, it is useful to consider these very practical considerations about how, whether, and why some policies are likely to succeed and others are not.

Some of the earliest work on this subject was by Robert Nakamura and Frank Smallwood, in a book titled The Politics of Policy Implementation (1980). In that work, Nakamura and Smallwood broke policy implementation into three stages, and described

the key actors and key constraints at each stage. They view the stages in a linear, one-at-a-time sense, a view which is not shared by some later analysts.

In their first stage, policy formulation, the key actors are the governmental leaders, including the executive (President, Governor, Mayor) and the legislative branches, as well as individuals and interest groups. The individuals or interest groups will be motivated to act by a long-standing interest or by some type of crisis. In their framework, this stage ends when government adopts a decision. The key actors in this stage – especially the government actors -- often do not have the time or interest to be deeply involved in later stages. For that reason, it is important that the policy that they adopt be clear in its goals and that it specify the anticipated means. However, the actors at this stage are often hampered by a lack of knowledge about the details of the situation to be addressed by their policy, and they may not be prepared or well-suited to deal with the conceptual complexity of the issue before them. In those cases, the gaps they leave in their decision must be filled by participants in the next stage of the process.

Nakamura and Smallwood's second stage is policy implementation. The key actors in this stage may include the policy makers, but typically they will delegate responsibility for implementation to bureaucrats. Other key actors will be lobbyists, interest groups, recipients, consumers and the media. The key issues to consider at this stage are the internal procedures used by the implementers, the allocation of resources by the implementers, and the psychological motivations of the implementers. This stage does not end until the policy is terminated.

Nakamura and Smallwood's final stage is policy evaluation, in which the key question is how close the program came to achieving its stated goals. The actors at this stage may be the same as those from stage one or two, although often they are academics or public interests groups. They caution, though, that evaluators often do not have much political power. Nakamura and Smallwood believe that only "professional evaluators" can conduct an objective evaluation, and that an objective evaluation must be based on clear and specific criteria for success and representative sampling. They believe the key evaluation questions are to identify the policy goal, to characterize the program activities in terms of the goals, to define performance indicators, and to gather data on outputs (actions), outcomes (consequences) and impact (long-term consequences).

Treating the same subject more than 20 years later, in a book titled managing Policy Reform: Concepts and Tools for Decision-Makers in Developing and Transitioning Countries, Derrick Brinkerhoff and Benjamin Crosby refined many of the concepts previously articulated by Nakamura and Smallwood (Brinkerhoff & Crosby, 2001). They began by noting six important points about policy change, several of which resonate with concepts first articulated by Nakamura and Smallwood: (1) the impetus for change in policy often comes from outside the government, or from new government leaders; (2) policy change decisions are highly political, meaning that there are winners and losers, and the identity of the winners and losers can have important implications for the policy; (3) usually, it's the technocrats who are the most involved in implementing policy, and their goal is usually to maximize output, which is different from the goals of most political leaders; (4) reformers are often unfamiliar with government policy

operations, and veteran bureaucrats know that reformers can often be worn down by delay or other tactics; (5) the resources needed for policy change are often hard to find, and generally have to be re-allocated from somewhere else; (6) there is inertia slowing government organizations from adapting to new tasks.

Brinkerhoff and Crosby have a six-task list of policy implementation tasks. These stages are roughly sequential, although not as linear as Nakamura and Smallwood's three stages. By blurring Nakamura and Smallwood's clear delineation between policy formulation and policy implementation, Brinkerhoff and Crosby are able to raise important issues that were not fully developed in the earlier framework. On the other hand, Brinkerhoff and Crosby do not pay as much attention to policy evaluation, since it is no longer given equal weight to formulation and implementation. For these reasons, it is useful to consider the two frameworks together.

Brinkerhoff and Crosby's first task is policy legitimization, which they describe as finding someone to champion the new policy. This is especially important if the new policy is contentious or represents a major shift from the prior status quo. Step two, which is closely related to step one, is constituency building. Brinkerhoff and Crosby describe this task as identifying "the winners" under the new policy – the consumers of services, the providers of inputs, the officials within the implementing agency whose authority will be enhanced by the new policy. One would expect both of these steps to occur during Nakamura and Smallwood's "policy formulation" stage, although they would likely continue past that point in time as well.

Brinkerhoff and Crosby's third task is something not fully addressed by Nakamura and Smallwood: resource accumulation. They included resource allocation as part of policy implementation, but in fact this task must be initiated earlier in the process if the policy is to be successful. Both people and funds need to be allocated (or, more realistically given budget constraints, reallocated) to effectuate the new policy. Brinkerhoff and Crosby warn that "the losers" under the new policy will try to resist progress on this stage. Those who want the policy to succeed therefore need to identify who the losers may be and what their strengths are

Brinkerhoff and Crosby's fourth task also was not fully developed by Nakamura and Smallwood: organizational design. Brinkerhoff and Crosby recognize that effective policy implementation requires an appropriate organizational structure to work in support of the policy, and that because of the inherent inertia and conservatism of organizations it is often easier to create a new structure than to try to retool an old one – although pre-existing organizations may continue to interfere with the workings of the new organization (or funds or personnel for a new organization may not be available). Nakamura and Smallwood, who addressed the internal procedures and psychological motivations of the implementers, apparently had some of the same concerns in mind, but in my view the structure of an organization includes those issues but goes beyond them, and provides a more concrete way of thinking about those potentially amorphous ideas.

Brinkerhoff and Crosby state that their fifth task is where implementation moves from paper to action: mobilizing resources and actions. This task consists of pilot projects, roll-out of the new policy, and ultimately full coverage. At this stage it is

critical to pay attention to the incentives for policy actors to adopt new practices, and make sure that the incentive structure fosters the desired behavior.

The last task in this rubric is monitoring progress and impact. The biggest analytical difference here is that Brinkerhoff and Crosby see this as an ongoing process that should begin early on, as opposed to a final stage that begins only after the program is terminated. However, Nakamura and Smallwood are much more explicit about how policy should be monitored, and by whom, and it is in the context of this task that their early work retains the most value.

In Effective Policy Implementation, Daniel Mazmanian and Paul Sabatier take a more analytical approach to policy implementation, not breaking it down into tasks or stages but rather considering broad themes and questions that are bound to affect the success of a policy (Mazmanian & Sabatier, 1981). As they explain, if these issues are kept in mind during the formulation and implementation of a new policy, the policy will be more likely to succeed.

One of Mazmanian and Sabatier's major themes is the tractability of the problem addressed by the policy. They note that problems are more tractable when there is a technological fix for the problem, and when the causal link between the problem and the fix is clear. Problems are also more tractable when the behavior that we want to change or proscribe falls into a limited range, and when the number of actors whose behavior must change is relatively small, and when the extent of behavioral change needed is not great.

Mazmanian and Sabatier's second theme is the coherence of the new policy as incorporated into statute or of the structures created by the new statute. Are there clear objectives, and are objectives prioritized? Do officials have sufficient authority and resources (funds, staff, technical analysis, administration, monitoring) to implement the new policy? If more than one agency is involved in implementing the policy, is there hierarchical integration among the implementing agencies? If not, problems are likely to arise as issues fall into gaps between agencies or languish as a result of disputes between non-hierarchically integrated agencies. Finally, to the extent that there are rules built into the policy, such as the organization of new agencies, requirements for public participation, and the like, do those rules foster the objectives of the policy, or will they hinder achievement of objectives?

Mazmanian and Sabatier's third theme is non-statutory coherence. Here, they raise issues such as the socio-economic conditions of the target group in particular, and of the larger community in general. They also remind us to consider the severity of the problem being addressed, media attention to the problem, public support for the statutory objective (which remains a factor even after a new policy has been adopted), the commitment and leadership ability of supportive implementing officials. They remind us, as well, that all of these factors are likely to vary over time, and that a "snap-shot" assessment of these factors can soon be out-dated information.

2.5.4. Policy Tools

Lorraine McDonnell and Richard Elmore describe four specific tools, or "policy instruments" that can be used to implement policy choices. Mandates are rules. We set

rules, we expect compliance with them, and we compel compliance via the use of penalties. Inducements are conditional grants of money, creating incentives for some portion of the population to change their behavior. Those who do not take the inducement will not change their behavior, so this tool is only appropriate for situations where a range of behavior is an acceptable outcome. Capacity-building generally refers to educational or other outreach efforts that are viewed as an investment in long term change. Finally, system changing refers to adding or eliminating a government function. With this tool, the system by which public goods and services are delivered is changed – from one agency to another, from public agency to private, or from private to public. System-changing reflects a recognition that the existing institutions are not working, and that change is needed, but it often creates a new set of challenges in uncharted waters. (McDonnell & Elmore, 1987).

CHAPTER 3: MODELING THE EFFECTS OF AN URBAN GROWTH BOUNDARY ON VEHICLE TRAVEL IN A SMALL METROPOLITAN AREA

3.1. Abstract

An integrated land use – transportation model was used to simulate the impact that an urban growth boundary would have on vehicle miles of travel in a small metropolitan community over a 40-year modeling horizon. The results of the modeling effort indicate that even in an area with low to moderate population growth, there is the potential to reduce vehicle miles of travel per person by as much as 25% from a business-as-usual scenario over a 40-year period, while still maintaining moderate population density, even in the urban core of the region. The reduction would result primarily from a shift from driving alone to carpooling, using public transit or walking for many trips. An urban core scenario would also benefit from shorter average trip lengths; a scenario with multiple village centers would not have shorter trip lengths, but would still have significant improvements in total vehicle miles of travel.

3.2. Background

Vehicle Miles Traveled (“VMT”) is a measure of how much driving a person or a population does in a given period for time. VMT per capita is viewed as the strongest single correlate of environmental degradation and resource consumption in the transportation sector (Cervero & Murakami, 2010). Since the dawn of the automobile age, VMT in the United States has steadily increased. In 1940, people drove an average

of 2,300 VMT per person (Federal Highway Administration, 2010). By 1980, the annual average was up to 6,700 VMT per person, and by 2008 the average had soared to 9,800 miles per person (Federal Highway Administration, 2010; Sears & Glitman, 2010). All of this driving has significant implications for the environment, natural resources, public health, traffic congestion and safety, and social justice.

There are many potential mechanisms for reducing VMT. Potential strategies include technical innovations, educational campaigns, fuel or other driving-related taxes, and more. This paper explores a fourth type of solution. The solution considered here relates to modifying the built environment, over time, to bring people and jobs closer together. The idea is to have people living and working in spaces that make walking, biking, and public transit feasible and enticing, so that people naturally choose to drive less.

3.2.1. Connection between the Built Environment and VMT

Many researchers have attempted to clarify the connection between descriptors of the built environment, such as density, diversity of land use, and design, and travel measures, such as VMT per person, trip counts, and Vehicle Hours of Travel per person. Results are typically reported in terms of elasticity of travel behavior to different built environment characteristics. Although it is not necessarily the most important aspect of the built environment for purposes of predicting travel behavior, by far the most studied aspect is population density. One recent study found that the elasticity of VMT to increasing population density was -0.38, meaning that a 10% increase in population

density was correlated with a 3.8% decrease in VMT per capita (Cervero & Murakami, 2010).

Other studies have found smaller effects. Another recent study of data found that the elasticity was only -0.19, meaning that a 10% increase in residential density was correlated with a decrease in VMT of 1.9% (Heres-Del-Valle & Niemeier, 2011). A meta-analysis of the data from 50 studies found an even weaker connection: The range of elasticities of VMT to density across the underlying studies was -1.05 to +0.03, and the weighted average elasticity was -0.04 (Ewing & Cervero, 2010). In this study, VMT was most sensitive to distance to downtown (also called destination accessibility), with a weighted average elasticity of -0.22, and job accessibility by automobile, with a weighted average elasticity of -0.2.

Despite the work that has been done to clarify how to measure the various aspects of the built environment that are expected to affect VMT, studies still have widely varying results. Part of the problem is that overall effects are small, and other factors, such as household income or employment status, may dwarf the effect of the built environment on travel behavior. Although it is possible to control for these variables, a lot of detail is lost in the process of controlling, and significant distortions may thus affect the results. Some researchers have found that attitudinal and lifestyle variables are more important than built environment characteristics (Bagley & Mokhtarian, 2002). Another significant problem is the limitations of the available data, particularly longitudinal data that could clarify the difference between correlation and causation, not to mention the inherent difficulty in establishing causation in any complex interaction.

3.2.2. Scenario Analysis

In this field, scenario analysis is used to predict the effect that a change in land use will have on future travel patterns. Statistical analysis quantifies the relationships between urban form and travel patterns; simulation studies then use the quantitative relationships to make predictions (Handy, 1996). A scenario is “not a forecast, but one possible future outcome” (Bartholomew, 2007). The variables most often studied in scenario analysis include the location of growth, the density of growth, land use diversity, and transportation system elements (Bartholomew, 2007).

Scenario studies also typically report more detail on density than on other built environment attributes. A meta-analysis of 23 scenario studies found a linear relationship between density and VMT across the studies, under which a 10% increase in density would lead to a 5% reduction in VMT and a 50% increase in density would lead to a 16% reduction in VMT (Bartholomew & Ewing, 2009). Other statistically significant variables included whether or not the scenario promoted mixed land use, and whether or not it included infill or compact development (Bartholomew & Ewing, 2009).

An earlier meta-analysis of scenario studies by the same researchers similarly found that a 50% increase in density over a 43 year time frame would lead to a decrease in VMT of 18% (Ewing, et al., 2007). By contrast, a third study found that doubling residential density across a metropolitan area might lower household VMT by only 5 to 12% (perhaps by as much as 25% if the increased density were coupled with higher employment concentrations, significant public transit improvements, mixed uses, and other supportive demand management measures) (Transportation Research Board, 2009).

The most important differences driving the differing results of these studies were the assumptions about growth rates and the rate of replacement of existing land uses.

Other meta-analyses of scenario studies have reached similar conclusions. An analysis of results from 22 scenario studies found that land use changes alone led to predicted decreases in VMT with a median of 4.9% at 10 years, and an almost 50% decrease after 40 years (without specifying the change in density) (Rodier, 2009). This study found that the largest overall effect on VMT over the 40-year time horizon was for combined strategies that included land use changes, tax strategies, and transit policies, such as increased frequency of transit service (Rodier, 2009).

3.2.3. Research Gaps

Existing studies involve larger geographic areas than Chittenden County, and areas where the population is already more dense than it is in Chittenden County. In part because of the size of the populations they are dealing with, the existing studies mostly use aggregate data; and many of the scenario studies use minimal computer modeling. Finally, the existing studies most often are set in places with more robust public transportation systems. It is reasonable to question whether similar effects will be observed in a place with a smaller, less densely-situated population, particularly when it is more difficult to shift to public transportation because the transit options are limited. These questions make the current project a useful addition to the literature on this subject.

3.3. Objective

What can an integrated land use- transportation model tell us about the potential for decreasing VMT in a small metropolitan area by changing the permissible land use? Specifically, if new development is proscribed outside the central core, does the model predict that VMT be reduced compared to a business-as-usual scenario, and if so, by how much? And, what will the resulting land use patterns be like, in terms of residential density and commercial-residential mix? Alternatively, if new development is permitted in traditional village centers scattered throughout the region in addition to the urban core, what does the model predict will be the impact on VMT and on land use?

Using an integrated land use-transportation model to simulate the changes in land use regulations will inform the debate on whether changing the land use regulations is a worthwhile tool for reducing VMT. The scenarios are not intended to be completely realistic, and the results are not intended to be a prediction of the future. More realistic scenarios would allow some development outside the UGB. However, the complete prohibition on development outside the UGB allows us to measure the maximum potential of this strategy, and to get a sense of what the resulting built environment would be like. Relaxing these restrictions might give more realistic results, but would leave open the question of how much improvement is possible with this technique. As work on this concept progresses, future research might include testing the results if a limited amount of development were permitted outside the UGB. For purposes of the present project, the purpose is to evaluate the potential benefits, and get a sense of the order of

magnitude of change that might be observed, so that debate on changing land use can be more fully informed.

3.4. Methods

3.4.1. Study Area

Chittenden County is located in the northwestern part of the state of Vermont. It is the most populous county in the state, and home to the state's largest city, Burlington. It is approximately 100 miles from Montreal and 150 miles from Albany, the two closest major cities. It is bounded to the west by Lake Champlain, and by farming communities on all other sides. Its total area is 620 square miles, but its total land area is only 539 square miles. The main roads in Chittenden County are Interstate 89, and US Routes 7 and 2.

Chittenden County consists of 18 municipalities, ranging in size from Buell's Gore, with a population of less than 20 people, to Burlington, with a population of 42,417 as of the 2010 census. The total population of the county was 131,761 in 1990, 156,545 in 2010, and is projected by the local regional planning commission to be 230,798 in 2030 (Economic and Policy Resources, 2000, 2001).

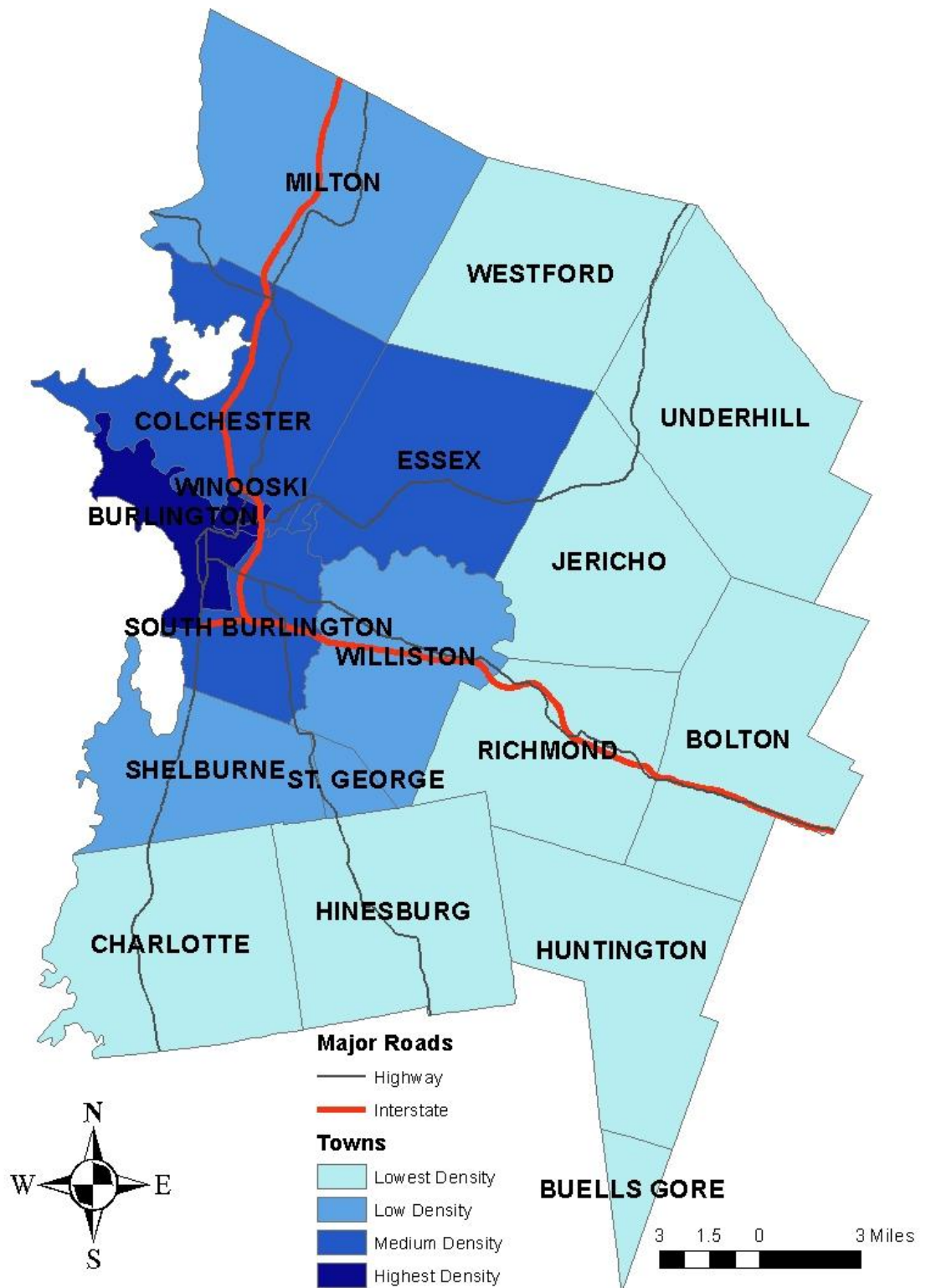


Figure 1: Study area

3.4.2. UrbanSim/TransCAD

UrbanSim is a land use allocation model that is designed to be integrated with a travel model (Hunt, et al., 2005; Waddell, 2002). It spatially allocates the development of real estate and the movement of households and businesses for a region based on externally derived forecasts of population and employment change, using a series of discrete choice models developed and estimated for the area based on base year and historical data (Voigt, et al., 2009). Agents in UrbanSim include households, employers, and real estate developers. UrbanSim takes as inputs existing land use, suitability for development, zoning restrictions, demographic data about residents and commercial data, as well as the population and job forecasts.

UrbanSim as implemented for Chittenden County has been integrated with the county's travel demand model, which was developed using TransCAD v.4.9 (Caliper Corporation) (Voigt, et al., 2009). The travel demand model is a four-step model, based on a road network that covers the entire county and 335 traffic analysis zones (TAZs) within the county plus 17 external TAZs that reflect traffic entering and/or leaving the county on major roads (Resource Systems Group, 2008). Using land use data regarding population, jobs, commercial space, and density, the model determines the number of incoming and outgoing trips generated by each TAZ, connects the start and end points of each trip, determines which mode (drive alone, carpool, walk/bike, or transit) will be used for each trip, and assigns each trip to a particular route on the network.

In the integration of the travel demand model with UrbanSim, the land use portion of the model runs for every year of the simulation. Once every five years of land use simulation, the land use data is aggregated to the TAZ scale and passed to the travel model. The land use data that is relevant to the travel model includes the number and attributes of households and employers in each TAZ (Resource Systems Group, 2008). This data directly affects the number of trips to and from each TAZ, which, in turn, affects the total amount of travel (VMT) within the model system, as well as the congestion levels on the various routes. After the travel model runs, various accessibility measures for each TAZ are passed back to UrbanSim, where they become part of the land use decision-making process for each future year of the simulation, as covariates in certain of the discrete choice submodels (Voigt, et al., 2009). Because mode choice in Chittenden County is heavily dominated by auto travel, auto accessibility is the dominant determinant of overall accessibility for each TAZ.

3.4.3. Scenario Development

The business-as-usual scenario reflects the model as estimated for Chittenden County based on 1990 baseyear data (Voigt, et al., 2009). It relies on population and employment forecasts from the Chittenden County Metropolitan Planning Office and Regional Planning Commission.

In developing the contours of the urban core scenario, in which no new development was permitted outside an urban growth boundary, the goal was to keep the area within the UGB as compact as possible, taking into account the existing road network and development patterns. As with the business-as-usual scenario, the urban

core scenario was run using a 1990 base year. In order to avoid a completely counter-factual scenario, major developments that were built between 1990 and the present were taken into account and the UGB was drawn to encompass them. In addition, we ensured that the area and zoning regulations inside the growth boundary would allow for the amount of anticipated growth.

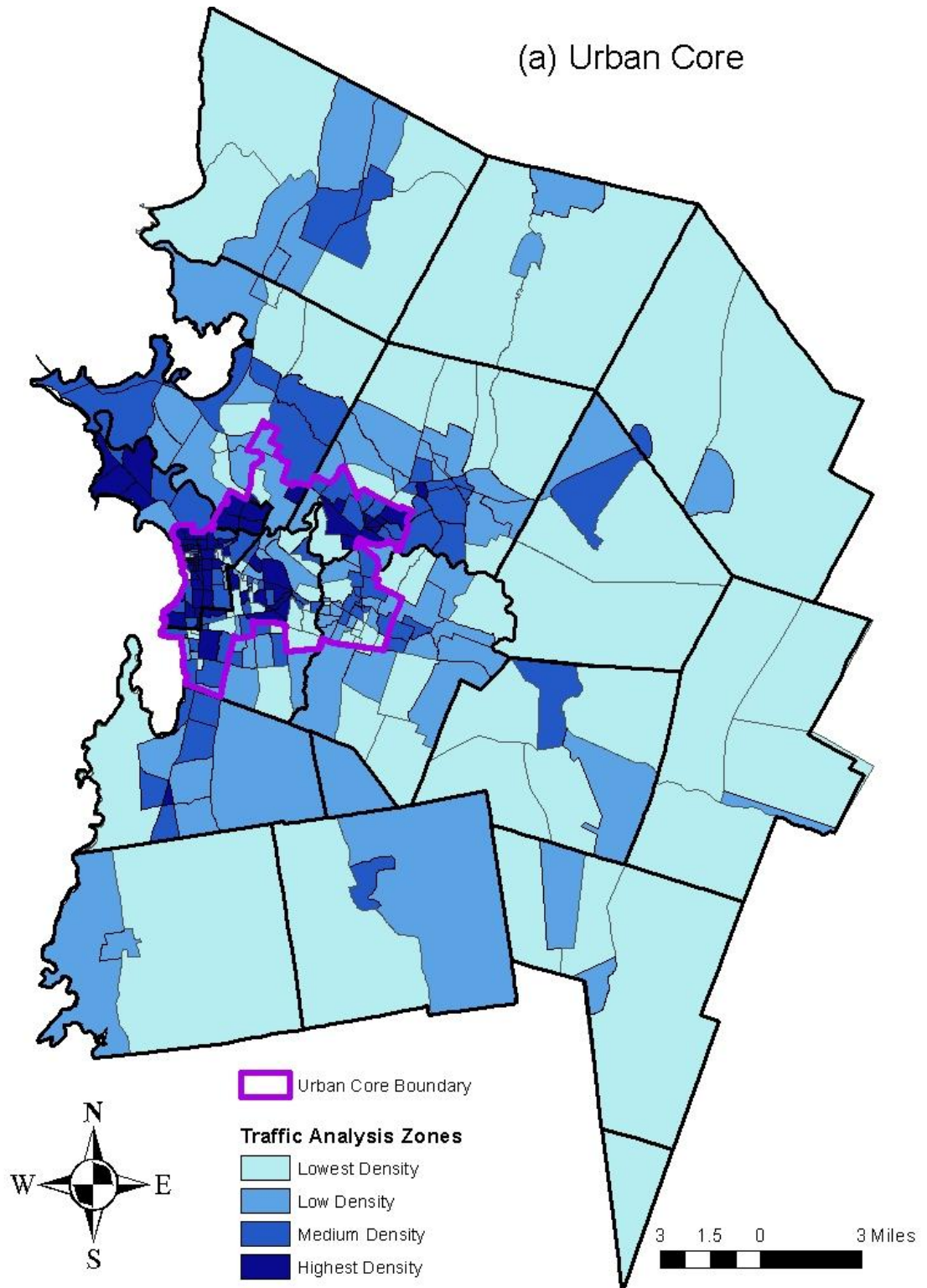
Once the boundary was set, all gridcells outside the boundary were modified to prohibit any new residential, commercial, or industrial development. Zoning restrictions inside the growth boundary were not modified, so that growth could occur within the boundary up to the existing limits, but would not occur outside the boundaries at all.

The intent of the multi center scenario was to spread growth around, while still requiring that it be relatively compact in those places where it is permitted. To implement this scenario, one or more TAZs were selected from each town in the county. Most towns have a small TAZ in the traditional town center, and one or more additional TAZs covering the remainder of the town. For all towns with a central, compact TAZ, that TAZ was chosen for growth. In Colchester, the area that has been designated as a growth center was chosen. The gridcells in those TAZs that were selected as the growth areas kept their existing zoning regulations; all other gridcells were modified to allow no development of any type.

Table 1: Scenario Summary

Scenario Name	Description
Business as Usual	<ul style="list-style-type: none">- Land use and zoning limits on development reflect actual regulations as of 1990 throughout the county
Urban Core	<ul style="list-style-type: none">- Land use and zoning limits in a central core of 31 square miles, as depicted in Figure 2(a), reflect actual regulations as of 1990- In the balance of the county, no new development is permitted- Existing properties can still be used in the “no growth” area, and people and businesses can move in and out freely
Multi Center	<ul style="list-style-type: none">- Land use and zoning limits in 16 town or village centers covering a total of 41 square miles, as depicted in Figure 2(b), reflect actual regulations as of 1990- In the balance of the county, no new development is permitted- Existing properties can still be used in the “no growth” area, and people and businesses can move in and out freely

(a) Urban Core



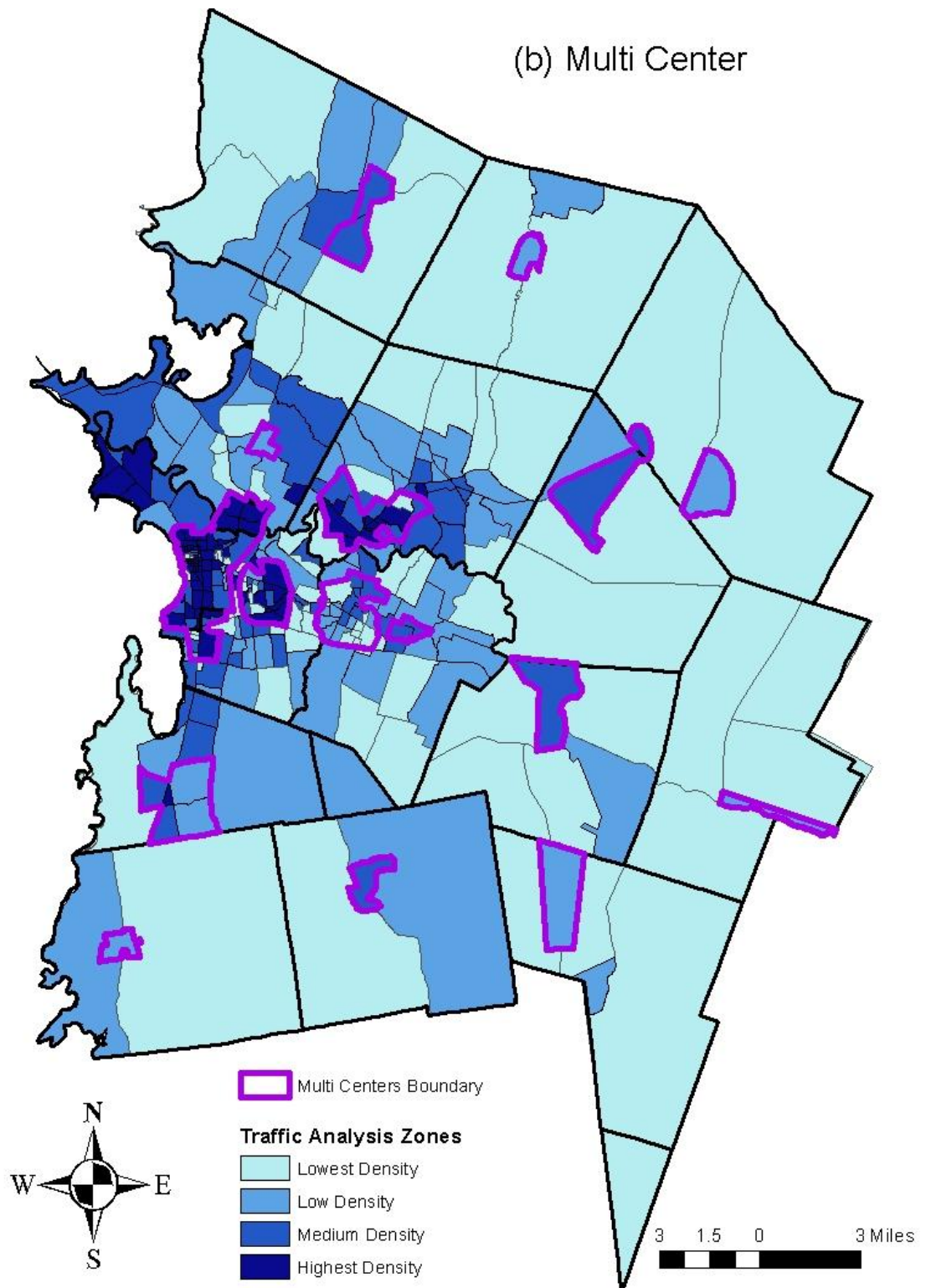


Figure 2: Borders of growth areas in (a) urban core scenario and (b) multi center scenario. Shading indicates residential density as of 1990.

3.4.4. Analysis

Land use and transportation indicators were generated from each model run to compare and evaluate the scenarios. Land use indicators were generated at three spatial scales: gridcell, TAZ, and town. The land use indicators included residential units, population, commercial and industrial square feet, and commercial and industrial jobs. Transportation indicators were calculated at the TAZ scale and included home access to employment and job access to employment (from UrbanSim), the overall accessibility of each TAZ, VMT, trips counts by each mode (drive alone, shared ride, walk/bike, or bus), and VHT (from TransCAD). The overall accessibility is a unitless measure that combines the utility of travel by auto, transit, and walking from a given TAZ to all other TAZs in the region.

The indicators were imported into a database and ArcGIS was used to join the data to the appropriate geographical region. The results could then be analyzed for different values inside and outside the urban core, the designated village centers, and other geographic designations.

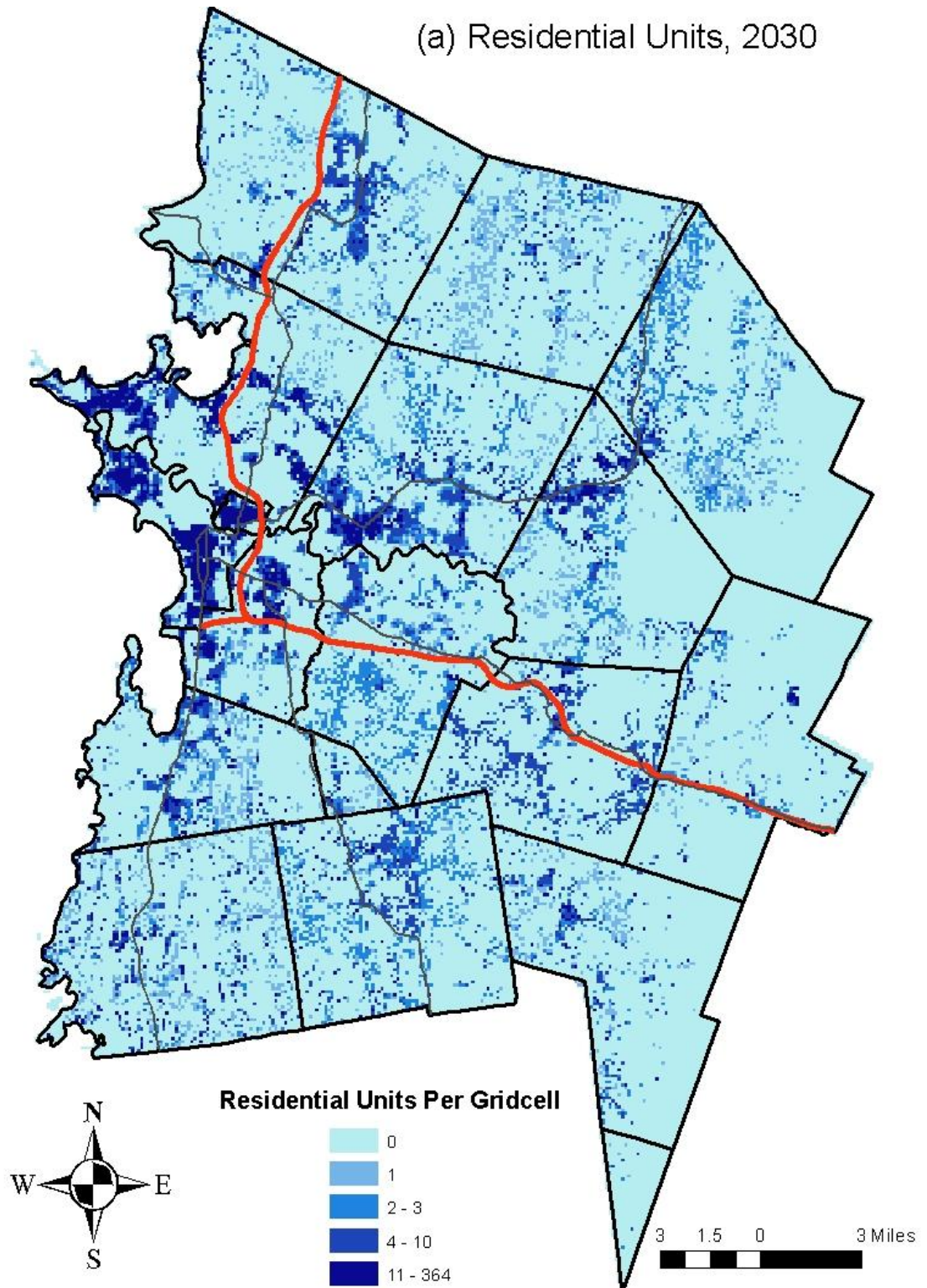
3.5. Results

3.5.1. Land Use Results

County-wide, population density increases over the 40 years of the model run from 0.32 people per acre in 1990 to 0.54 people per acre in 2030 (Figure 3a). Under the business-as-usual scenario, Burlington, the county's largest city, is forecast to grow from

4.9 people per acre in 1990 to 6.2 in 2030. Winooski, the most densely populated town in both 1990 and 2030, is forecast to grow from 7.1 people per acre in 1990 to 8.0 people per acre in 2030.

(a) Residential Units, 2030



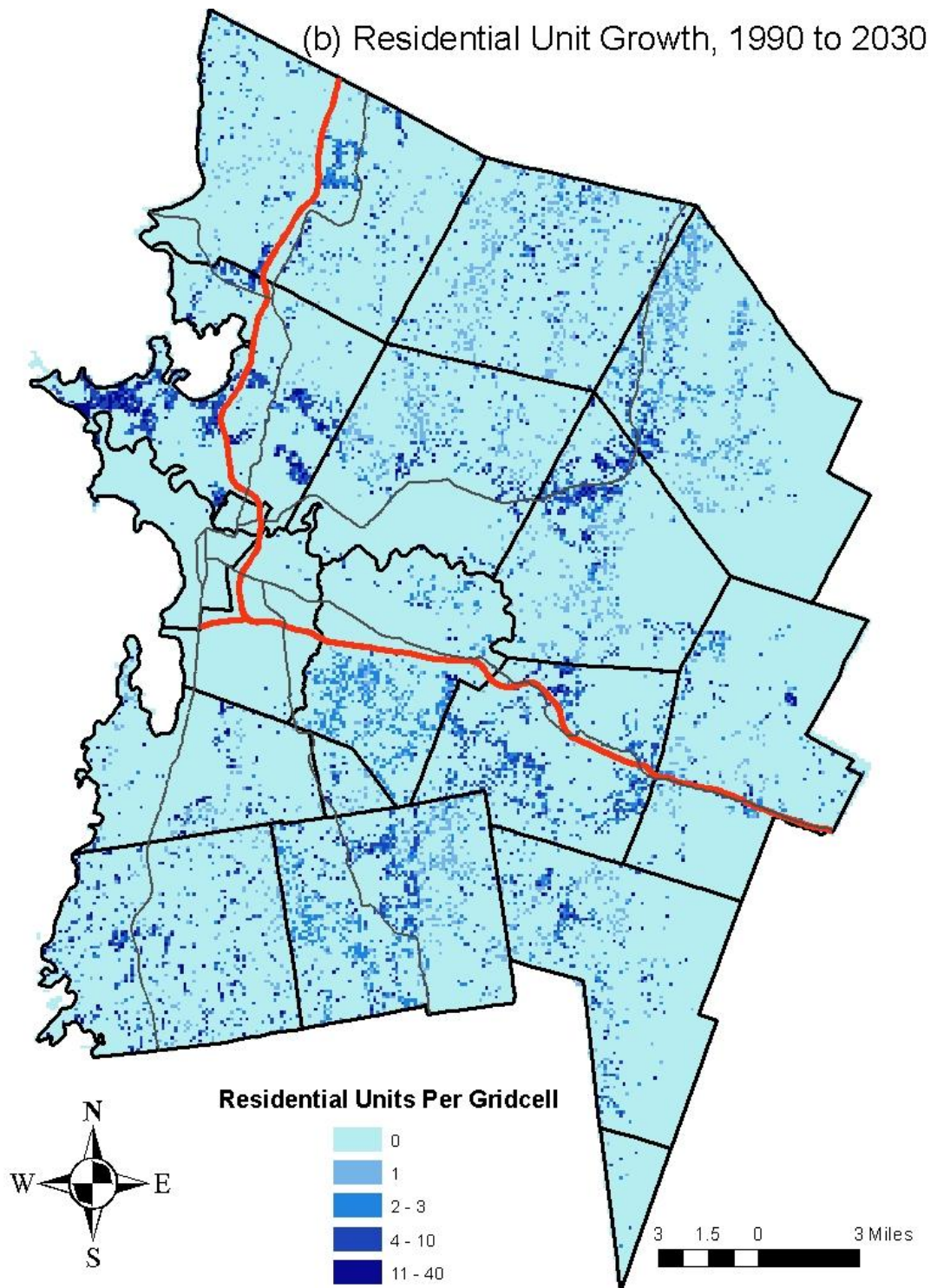


Figure 3: (a) Total residential density in 2030 under the business-as-usual scenario, and (b) residential unit growth from 1990 to 2030 under the same scenario.

The business-as-usual scenario yields widespread low density growth, with most new development occurring in rural areas (Figure 3b). This growth pattern is particularly evident in Williston, Hinesburg, Westford, and Underhill, towns that were predominantly rural in 1990. The towns with the least growth in residential units in the business-as-usual scenario are the three towns with the highest density in 1990: South Burlington, Winooski, and Burlington (Table 2).

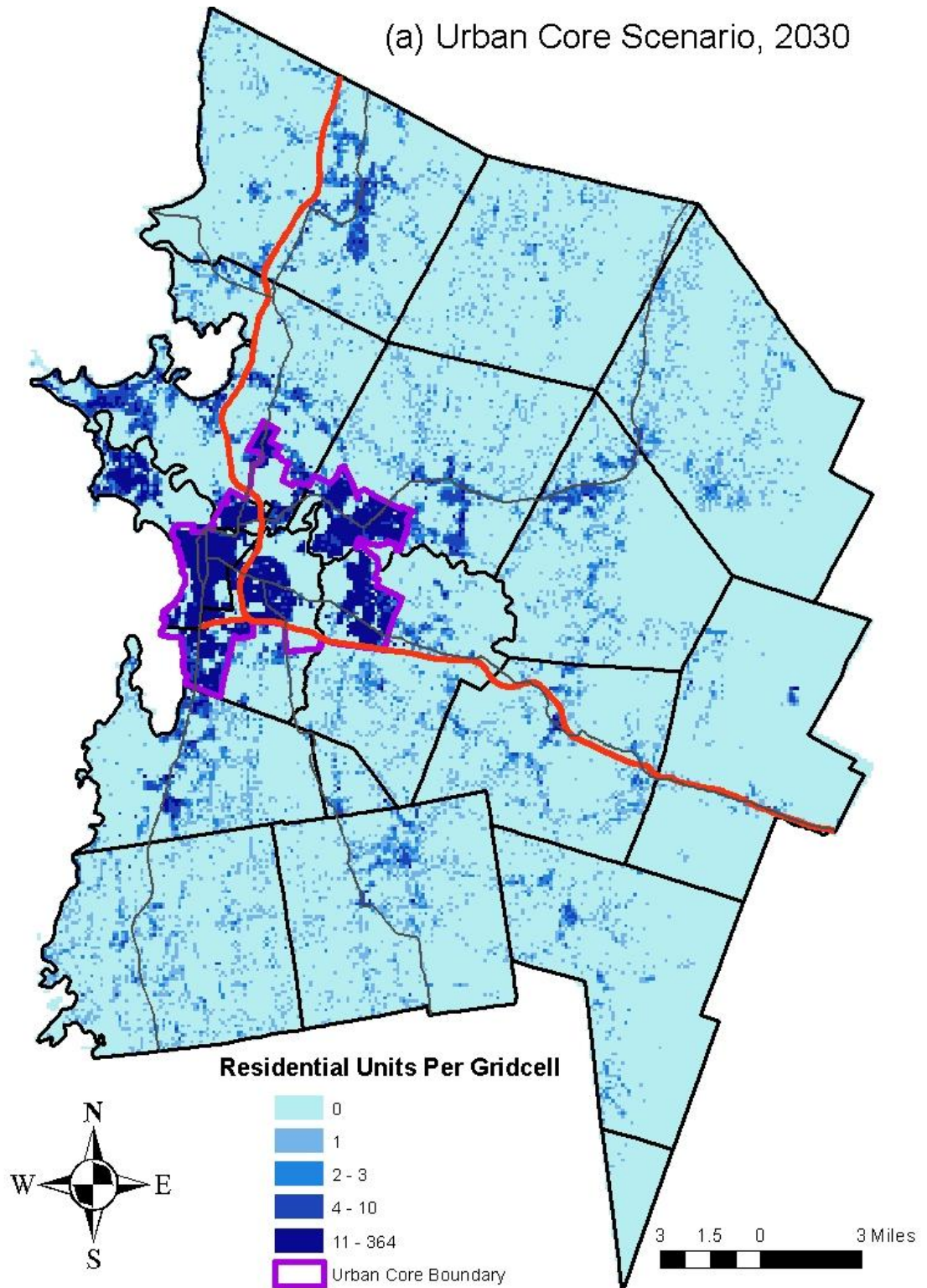
Table 2: Growth in residential units by town

Town	Baseline	Business As Usual Scenario			Urban Core Scenario			Multi Center Scenario		
	Residential Units 1990	Residential Units 2030	Growth	Percent Change	Residential Units 2030	Growth	Percent Change	Residential Units 2030	Growth	Percent Change
Bolton	526	1,764	1,238	235%	526	-	0%	704	178	34%
Buells Gore	8	49	41	513%	8	-	0%	8	-	0%
Burlington	16,280	16,517	237	1%	27,214	10,934	67%	26,581	10,301	63%
Charlotte	1,331	4,971	3,640	273%	1,331	-	0%	1,352	21	2%
Colchester	5,901	11,785	5,884	100%	8,445	2,544	43%	7,197	1,296	22%
Essex	6,317	8,206	1,889	30%	11,295	4,978	79%	10,222	3,905	62%
Hinesbury	1,476	4,780	3,304	224%	1,476	-	0%	2,077	601	41%
Huntington	616	2,268	1,652	268%	616	-	0%	1,186	570	93%
Jericho	1,500	4,463	2,963	198%	1,500	-	0%	2,176	676	45%
Milton	3,014	5,304	2,290	76%	3,014	-	0%	4,602	1,588	53%
Richmond	1,390	4,326	2,936	211%	1,390	-	0%	2,949	1,559	112%
Shelburne	2,356	3,683	1,327	56%	2,356	-	0%	4,167	1,811	77%
S. Burlington	5,413	5,568	155	3%	15,391	9,978	184%	11,426	6,013	111%
St. George	285	537	252	88%	285	-	0%	285	-	0%
Underhill	1,013	3,062	2,049	202%	1,013	-	0%	1,317	304	30%
Westford	637	2,459	1,822	286%	637	-	0%	853	216	34%
Williston	1,882	3,423	1,541	82%	5,153	3,271	174%	4,536	2,654	141%
Winooski	2,933	2,933	-	0%	4,391	1,458	50%	4,435	1,502	51%

The urban core scenario was run for the same years as the business-as-usual scenario, with the same population and job control totals. Thus, the county-wide growth and density is the same as in the business-as-usual scenario, although it is distributed differently throughout the county (Figure 4). The density in the area designated as the “urban core” is 2.8 people per acre in 1990, and it is forecast to grow to 4.7 people per acre in 2030 in the business-as-usual scenario. By contrast, in the urban core scenario the

density in that area is forecast to grow to 7.2 people per acre. Burlington's density ends up at 9.3 people per acre under the urban core scenario, almost 10% higher than forecast in the business-as-usual scenario.

(a) Urban Core Scenario, 2030



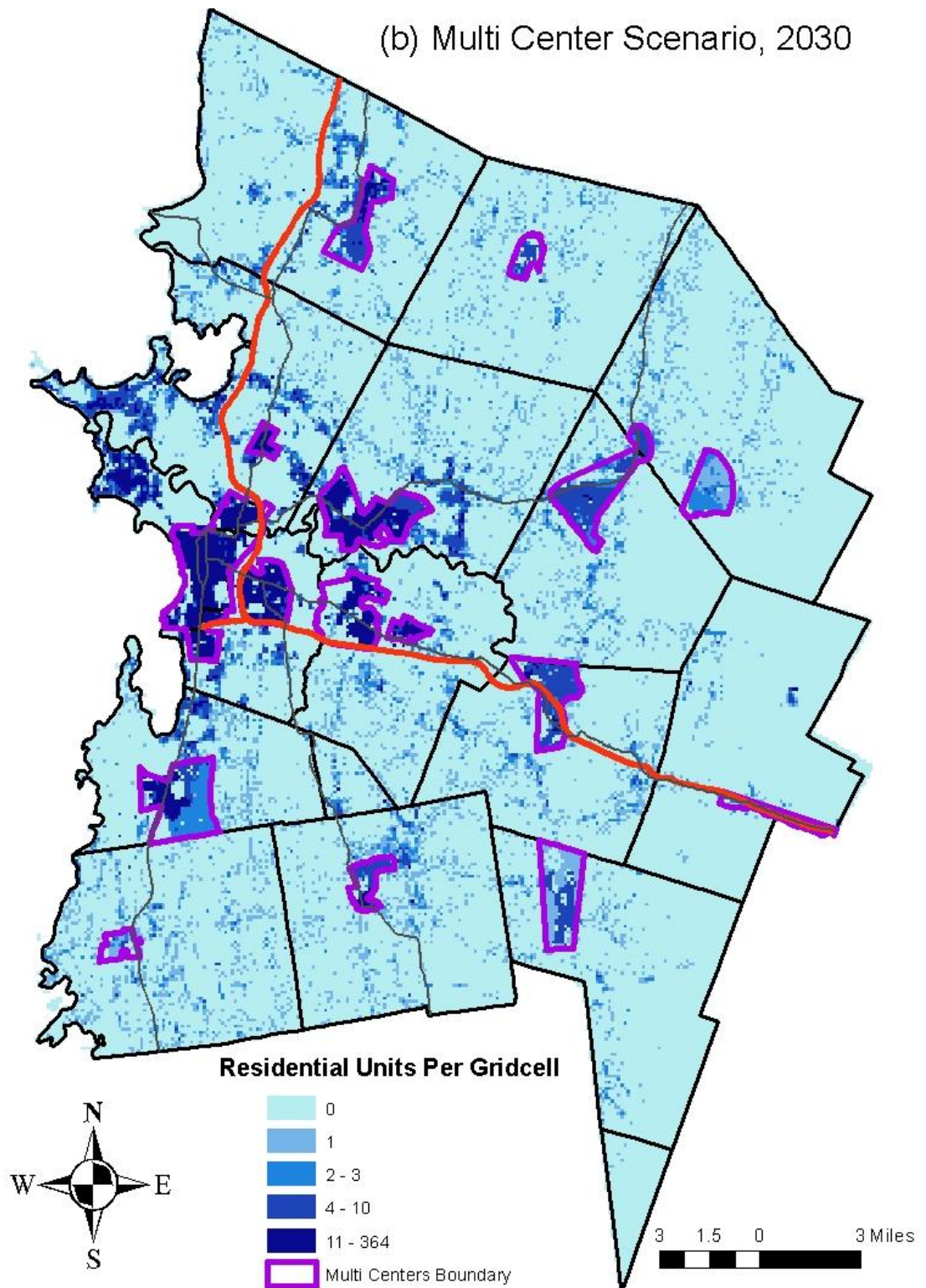


Figure 4: Residential units per gridcell in 2030 in (a) urban core scenario and (b) multi center scenario.

Turning to the multi center scenario, density in the areas designated as town centers increases from an average of 1.0 residential unit per acre in 1990 to 2.3 units per acre in 2030. By comparison, the business-as-usual scenario forecasts only 1.2 units per acre in these areas in 2030. Several town centers are limited in growth under this scenario by their current zoning regulations, which limit the maximum density they permit even in the town centers, such as Charlotte.

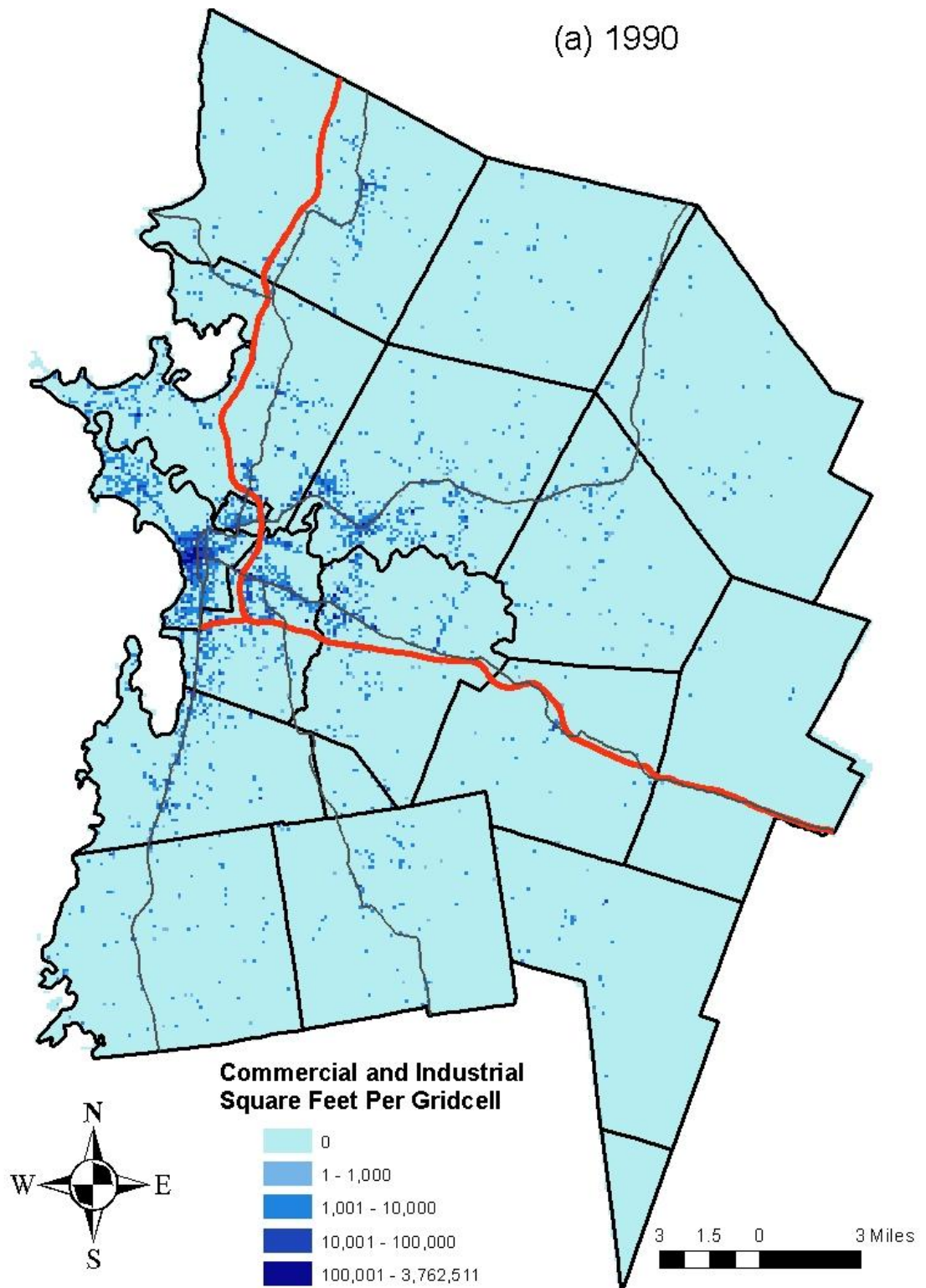
Another way to evaluate the population density is by looking at the proportion of land that is minimally developed, the proportion that is densely developed, and the proportion of the population living in low or high density areas. In the business-as-usual scenario, and measuring at the gridcell level, 14,000 more acres of land are forecast to have residential development over the 40 years of the model run (Table 3). Under the urban core scenario, the new growth would occupy only 4,400 acres, and with the multi center scenario it would occupy 8,100 acres. Under the business-as-usual scenario, no new land is forecast to have high density development (at least 10 units per acre). By contrast, the urban core and multi center scenarios increase the proportion of the population living at moderate densities (at least one residential unit per acre), and increase the amount of land that is densely developed by approximately 250 acres, in order to maintain the proportion of the population that is living at high density.

Table 3: Areas with varying levels of residential density.

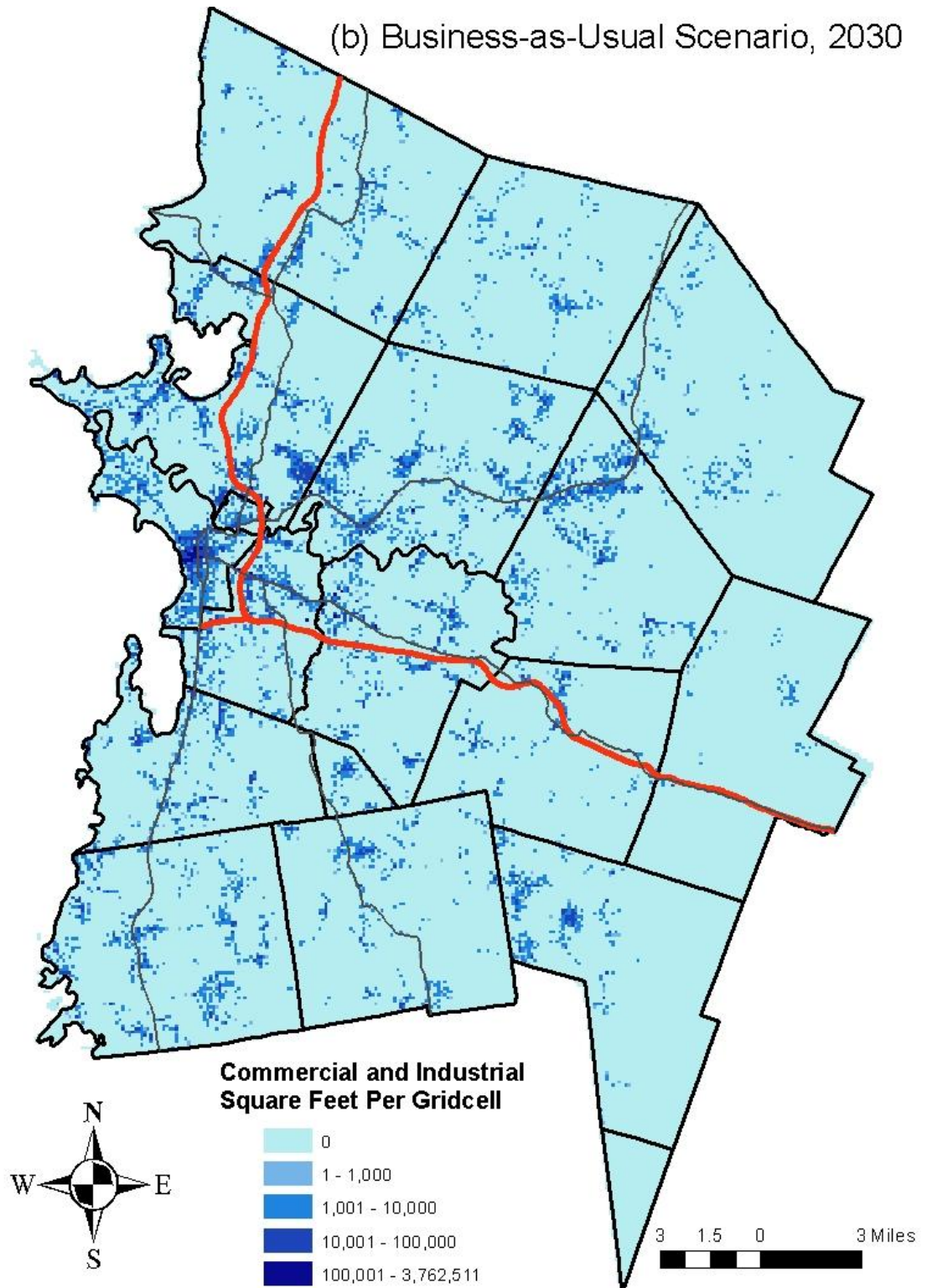
	Gridcells with any residential development			Gridcells with >1 residential unit/acre			Gridcells with >10 residential units/acre		
	Gridcells	Acres	Res Units	Gridcells	Res Units	Percent	Gridcells	Res Units	Percent
1990	11,531	64,111	52,878	1,939	37,306	71%	128	12,615	24%
2030 Business as Usual	14,062	78,183	86,098	4,402	65,936	77%	128	12,664	15%
2030 Urban Core	12,327	68,536	86,041	3,008	71,102	83%	172	20,226	24%
2030 Multi Center	12,999	72,273	86,073	3,126	69,090	80%	173	20,227	23%

Turning from residential development to commercial, under the business-as-usual scenario the largest portion of commercial growth is forecast to occur in the towns of Colchester, Charlotte, and Jericho, outside the urban core. In 1990 there was commercial or industrial development in only 2450 gridcells out of 64,000 in the county; by 2030, under the business-as-usual scenario, such development is forecast for 5868 gridcells.

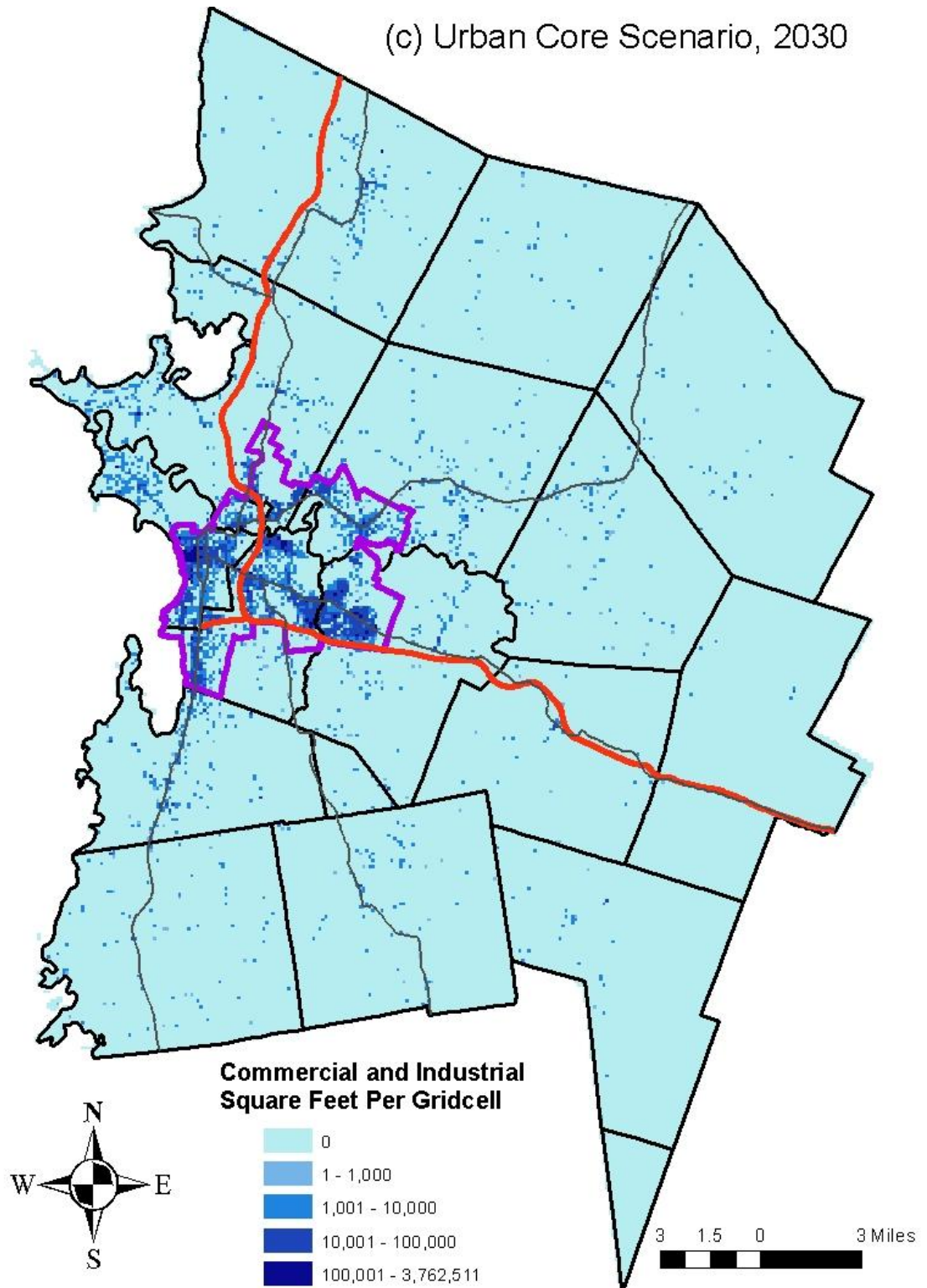
Under the urban core scenario commercial and industrial growth were limited to areas within the urban core where such development is permitted under existing zoning regulations. With these restrictions in place, the number of gridcells with such development is not forecast to increase the way it did in the business-as-usual scenario, growing from 2450 gridcells in 1990 to 3088 in 2030, although the total quantity of such space in the county overall is the same (because it is determined by the control totals). In the multi center scenario, commercial and industrial space spreads to 3121 gridcells. In this scenario, the commercial square footage in the areas designated as town centers almost doubles, compared to a projected 12% increase in the same areas under the business-as-usual scenario.



(b) Business-as-Usual Scenario, 2030



(c) Urban Core Scenario, 2030



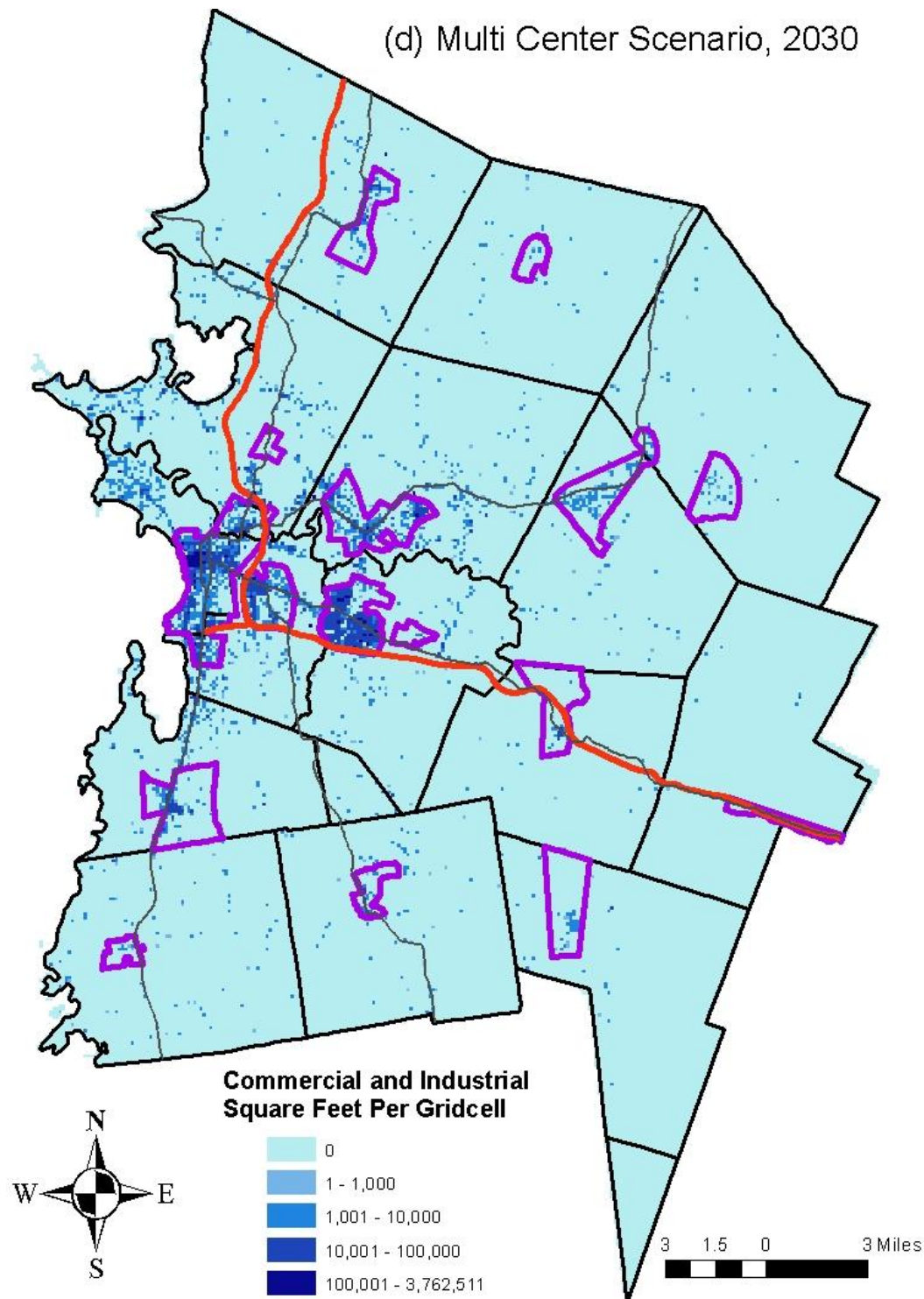


Figure 5: Commercial and industrial square feet per gridcell in (a) 1990; (b) 2030 under the business as usual scenario; (c) 2030 under the urban core scenario; and (d) 2030 under the multi center scenario.

The mix of residential and commercial development is another important land use indicator, and another way to evaluate scenario outcomes. In 1990, 113,344 people, or 89% of the population, lived within 400 meters (approximately ¼ mile) of a gridcell with commercial development (Table 4). By 2030, under the business-as-usual scenario, that number is forecast to grow slightly, to 195,950 people, representing 91% of the population.

Under the urban core scenario, by 2030 93% of the population is forecast to live within 400 meters of a gridcell with commercial development. Even though commercial development is much less dispersed under this scenario than under the business-as-usual scenario, a slightly higher proportion of the population can reach some commercial development on foot.

Table 4: Land use mix

	Gridcells with commercial space	Residential units in gridcells with comm. space	Residential units w/in 400 meters of comm. space	Percent of population w/in 400 m. of comm. space
1990	2,427	22,172	47,830	89%
2030 Business as Usual	5,333	33,995	76,870	91%
2030 Urban Core	2,904	43,019	80,337	93%
2030 Multi Center	3,159	42,701	79,517	92%

3.5.2 Transportation Results

In terms of transportation indicators, under the business-as-usual scenario, total VMT in Chittenden County is forecast to increase by 92% from 1991 to 2030 (Table 5).

VMT per capita is also forecast to increase, although only by 18%. The total number of trips is forecast to increase by 73% overall, but only by 6% per capita. In 1991, 69% of trips are by car with a single occupant, 19% are by car with more than one occupant, 12% are by walking or biking, and public transit is less than 1%. Those proportions are not forecast to change significantly in the business-as-usual scenario.

Table 5: Transportation results¹

	1991	2030 Business as Usual	2030 Urban Core	2030 Multi Center
Vehicle trips	40,715	70,409	64,586	54,263
Trips/capita	0.32	0.33	0.30	0.25
VMT	324,203	622,775	465,256	492,802
VMT/capita	2.6	2.9	2.2	2.3
VHT	13,296	24,873	19,679	20,533
VHT/capita	0.10	0.11	0.091	0.10
Walking trips	5,531	7,945	9,735	9,643
Bus trips	308	425	550	527

In the urban core scenario, with no changes to the transportation system or the travel demand model, VMT is forecast to be 25% lower in 2030 than in the business-as-usual scenario (Table 5), and the total number of vehicle trips is forecast to be 8% lower.

¹ Because the travel demand model from which these results are derived is a peak-hour model that uses only a portion of the actual road network, the results should not be considered to be predictions of actual travel levels. Rather, they should be considered as relative values, meaningful only in comparison to each other.

Walk-bike trips are 29% higher, and transit trips are 23% higher, although they still constitute less than 1% of the total number of trips.

Vehicle Hours of Travel (“VHT”) is also forecast to be lower in 2030 in the urban core scenario compared to the business-as-usual scenario, although the difference is not as great in percentage terms as the difference in VMT. The decrease is due to the decrease in trip count and in trip length, but the average travel speeds are forecast to be slightly slower in the urban core scenario (23.6 miles per hour) than in the business-as-usual scenario (25.0 miles per hour).

The results of the multi center scenario fall in between the business-as-usual scenario and the urban core scenario on almost every indicator, generally closer to the urban core results than to the business-as-usual results. This pattern is true for VMT, VMT/capita, and VHT.

3.5.3. Accessibility Results

TransCAD generates travel utilities, a measure of relative “cost,” for trips by automobile, transit, and walk/bike trips from each TAZ to every other TAZ. It then generates a logsum that combines the utilities for each of the three modes into a single measure of the relative accessibility for each TAZ. The logsum is dominated by the automobile utility, reflecting the dominance of automobile trips in the Chittenden County transportation system. By 2030, the business-as-usual scenario forecasts poor accessibility in many areas on the periphery of the core, shown in blue in Figure 6. These areas fare better in the urban core scenario. By contrast, the TAZs in the heart of the urban core become congested in the urban core scenario (TAZs in red in Figure 6). The

logsums for the multi center scenario are very similar to the business-as-usual scenario (Pearson's Correlation Coefficient >0.99999).

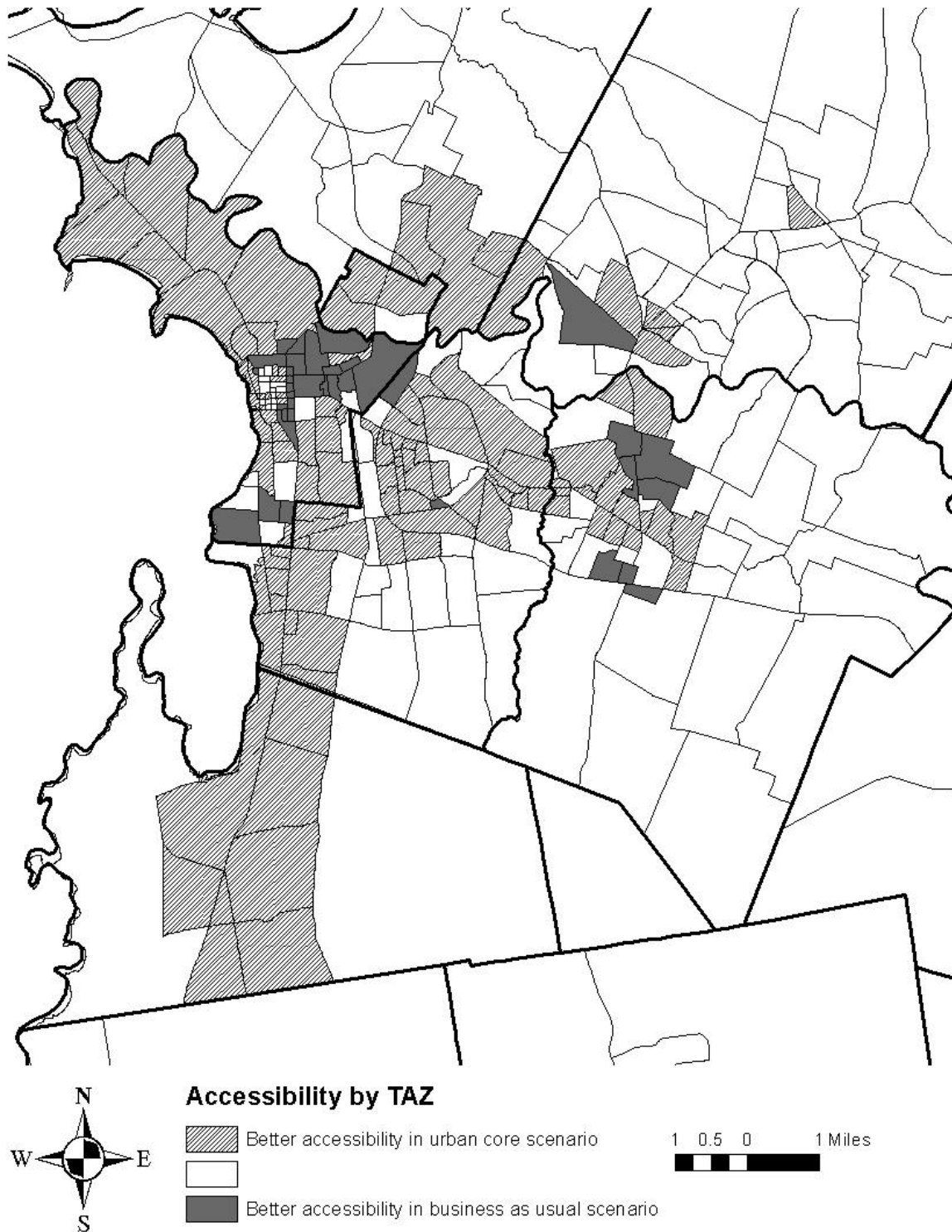


Figure 6: Difference in accessibility logsums in 2030 between the business as usual scenario and the urban core scenario. TAZs beyond the extent of Figure 6 had no meaningful difference in accessibility between the two scenarios.

The primary way that accessibility figures in the land use model is via the variables home-access-to-employment, which measures how many jobs can be accessed within a limited amount of time from a home in a given TAZ, and job-access-to-employment, which measures how many other jobs can be accessed within a limited amount of time from a job in a given TAZ. These measures incorporate the logsum data from TransCAD with the modeled land use results (UrbanSim Project, 2008). The home-access-to-employment variable is included in the residential development location choice model (where better accessibility makes the location more desirable for development), and the job-access-employment variable is included in the commercial development-location-choice model. Although other measures exist, these are the two that were determined to be useful predictors residential and commercial development within Chittenden County (Voigt, et al., 2009). Moreover, these are typical measures of destination accessibility, found to be the built environment variable most strongly correlated with VMT in a major 2010 meta-analysis (Ewing & Cervero, 2010).

In comparing these terms across the three scenarios, the values the model produces for each TAZ differ slightly from scenario to scenario, but in relatively terms there is almost no difference between the three scenarios. When broken into deciles, out of 335 TAZs, only 3 change decile from one scenario to another for either variable, and those only shift a single decile. The Pearson's Correlation Coefficient is greater than 0.9999 among the three scenarios for the 2030 values for both variables.

3.6. Discussion

3.6.1. Validation

Actual growth in Chittenden County between 1990 and 2010 has been significantly lower than modeled. The model inputs state that population will grow from approximately 127,000 in 1990 to approximately 165,000 in 2010, when in fact the population in 2010 is only 156,545 (US Census Bureau, 2011). While the difference between the actual and modeled population in 2010 is only 5% in absolute terms, there is a 29% difference in the amount of growth over the 20-year period from 1990.

Apart from the difference in the quantity of growth, actual growth has been in different locations than the model predicts under the business-as-usual scenario. Several close-in suburbs of Burlington, including South Burlington, Williston, and Essex, have a greater share of growth in reality than the model predicts, as does Milton, an outlying town with a significant commercial core. On the flip side, several of the more distant suburbs received, in reality, a smaller share of growth than the model predicts, such as Hinesburg, Westford, and Charlotte (US Census Bureau, 2011). The difference in the pattern of growth indicates that the model parameters, which were developed using the baseline 1990 data, do not perfectly reflect current trends. Changes may include growing preferences for shorter commutes, or other factors that favor the close-in towns over the more distant areas.

Comparing the transportation results to reality, the model predicted that VMT would grow by 11.5% per capita from 1990 to 2010 under the business-as-usual scenario. In actuality, VMT per capita growth in Chittenden County has been lower than the model

predicts, at approximately 6%. This is likely connected, at least in part, to the different land use patterns. In Vermont as a whole, over the same time period, VMT per capita has increased by almost 16% (VT. Agency of Transp., 2010).

3.6.2. Chittenden County results

The results of this modeling effort indicate that even with its relatively small size and slow rate of growth, Chittenden County can make significant changes to its land use patterns, and that those changes will result in significant shifts in its mobility profile, decreasing VMT and vehicle trips while maintaining or improving accessibility. Moreover, doing so will not result in undesirably dense or congested urban areas.

The densities that result from all three scenarios are within what the towns have already approved. Even the urban core scenario does not result in the kinds of density that would make Chittenden County or its core feel like a major city. It happens with moderate population growth, and the end result is moderate density. To put the scenario results in context, consider that Manhattan's population density is more than 100 people per acre over 23 square miles, and Boston and Chicago are both approximately 20 people per acre, over 48 square miles and 227 square miles, respectively (US Census Bureau, 2011). Burlington's actual population density in 2010 is 6 people per acre over just 11 square miles. Under the urban core scenario, the density in Burlington climbs to 9 people per acre by 2030. Almost 90% of the land area of the county is forecast to have population density of fewer than 5 people per acre. Only 1.2% of the land area is forecast to be more densely populated than 10 people per acre, although 38% of the population would live in those dense areas.

Even though the population density remains moderate, VMT and vehicle trips decrease significantly, especially under the urban core scenario. In future research, if the land use scenarios are combined with simulations of transportation changes, such as increasing bus service and/or increasing the cost of driving, the impact on VMT and vehicle trips will likely be even greater, and the minor congestion effect evidenced in the VHT results might be ameliorated.

It is important to bear in mind that these results are not predictions of the future, and that development is not likely to occur exactly as modeled in any of these scenarios. First, as we have seen, the business-as-usual model forecasts that growth will be more dispersed than it has been in reality, which means that the scenario analysis has likely exaggerated the transportation benefits of the modeled regulatory changes to some degree. Moreover, the urban core and multi center boundaries were drawn for purposes of exploring these ideas, and the precise boundaries of any urban growth boundary or other growth management tools actually adopted in Chittenden County would likely differ significantly from these preliminary and rough contours. However, the results are useful for getting an idea of the type and scale of benefits that might accrue from such a course of action.

3.7. Conclusion

As is the case with all models, the model results reported here only provide information about those variables that are included in the model. If a variable was not statistically significant in predicting outcomes in the past, it is not included for the

purposes of predicting future outcomes, even though attitudes can change over time and different variables may be of greater or lesser importance in different years. For example, the household location choice model focuses on variables such as the residential density, the average age of homes in the area, and the income level and family makeup of other residents of the area. It has no variables reflecting amenities like proximity to parks, to schools, or to shopping districts that might, in reality, have a strong influence on a household's decision of where to locate. In addition, even if they might be important, variables are not included if it is impossible or impractical to develop the data needed to include them, or they may be included via proxies that may or may not be good reflections of the variables that really matter.

These limitations necessarily impact the model results, and the model results must be interpreted with the included (and excluded) variables in mind. The inclusion of a variable reflecting the preference for young households to locate inside the core in the household location choice sub-model, for example, without changing the coefficient on that variable over the 40 year duration of the model run, may not reflect the reality that such preferences go in and out of style over time.

The lack of meaningful differences between the scenarios on the home and job access to employment measures suggests that the control totals do not anticipate enough growth to significantly affect accessibility, even with the extreme changes to the land use regulations reflected in the scenarios.

These limitations notwithstanding, the model and its results provide a useful way to structure our thinking about the potential of this particular VMT reduction strategy. At

the very least, it gives both professionals and the public something to react to, something to stimulate discussion about the land use we want to promote (or discourage), and the transportation outcomes we think would be beneficial.

3.8 References

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CHAPTER 4: POLICY IMPLEMENTATION ANALYSIS: ENACTMENT OF AN URBAN GROWTH BOUNDARY IN VERMONT

4.1. Abstract

This article considers the obstacles and opportunities for implementation of an urban growth boundary in northwestern Vermont, as a means to reduce vehicle miles of travel by changing the development patterns in the region. An urban growth boundary is a zoning or land use provision that redirects the real estate development activity in an area away from the open spaces in the periphery and back towards the urban core of the region. One pre-requisite for successful implementation of an urban growth boundary is the existence of a policy champion who can build support for the idea that ever-increasing vehicle travel is a concern, and that land use regulations can stem that tide. The second is a new regional-level entity, preferably one endorsed and supported by the state or federal government, to develop boundaries, design restrictions, create incentives, and ensure coordination among the many entities that would be involved and affected. If these two conditions are satisfied, the result could be a decrease in vehicle travel on the order of 25% over a 40-year time horizon. Such a desirable outcome justifies further exploration of this concept by the officials who could make it happen.

4.2. Introduction

Vehicle Miles Traveled (“VMT”) is a measure of how much driving a person or a population does in a given period for time. As researchers Robert Cervero and Jim

Murakami have stated, “VMT per capita is widely viewed as the strongest single correlate of environmental degradation and resource consumption in the transport sector – as individuals log more and more miles in motorized vehicles, the amount of local pollution (eg particulate matter) and global pollution (eg greenhouse gas, or GMG, emissions) increases, as does the consumption of fossil fuels, open space, and other increasingly scarce resources” (Cervero & Murakami, 2010).

The results of my land-use and transportation modeling efforts (reported elsewhere) suggest that if no significant changes are made to land use regulations or the transportation system, VMT per capita in Chittenden County, the most densely populated region of Vermont and the site of Vermont’s largest city, will increase by roughly 15% over a 40-year modeling horizon. However, if an urban growth boundary (“UGB”) were implemented, so that all new residential and commercial development was restricted to a relatively compact urban core, my modeling efforts indicate that VMT/capita would be reduced significantly. UGBs can be implemented with different policy tools and levels of government support. An evaluation of the efficacy of different UGB mechanisms is beyond the scope of this paper, but it has been addressed by others, including (Bengston, Fletcher, & Nelson, 2004), (A. Nelson, et al., 2007) and (Margerum, 2005). If a strong and effective UGB had been implemented in Vermont in 1990, VMT per capita would have been 25% lower in 2030 than it will be without the UGB. Of course, no such UGB was enacted in 1990. Were it to be enacted today, though, the impact would be expected to be similar. A critical question is whether such a boundary can be effectively implemented.

Over the past few decades, as government policies and programs have proliferated and the role of democratic government has continually grown, analysts have begun to think ever more deeply about the mechanisms for implementing policy decisions: what tools are effective, who are the key players, what type of situations derail well-intended policies (Brinkerhoff & Crosby, 2001; Layzer, 2002; Mazmanian & Sabatier, 1981; McDonnell & Elmore, 1987; Nakamura & Smallwood, 1980; Salamon, 2002).

This paper discusses the implementation of an urban growth boundary strategy in northwestern Vermont as a way to reduce VMT by changing the development patterns in the county. A UGB is a zoning or land use provision that redirects the real estate development activity in an area away from the open spaces in the periphery and back towards the urban core of the region. It does so by delineating two concentric regions. The inner region is the core, within which most or all new development should occur. The outer region, which forms a rough doughnut shape around the inner core, is the area in which new development is discouraged or forbidden. Beyond the outer region no new restrictions are imposed, usually because the area outside the second line is beyond the authority of the entity enacting the UGB. If implemented effectively, a UGB should decrease the need for area residents to drive long distances and drive alone, by fostering developments that are closer together and involve a better mix of uses, so that origins and destinations can be connected without the need for long driving trips.

4.3. Problem Definition

The essential first step in any policy implementation analysis is defining the policy problem. Defining a policy problem is essentially an empirical issue, but the data will often be tempered and filtered by political considerations. The way a problem is defined will draw attention to some aspects of the problem and minimize others. It can change the profile of the problem or the public's attitude towards the problem. It can also shape the range of proposed solutions and how the public views them (Layzer, 2002).

A good problem definition should begin with a description of the facts that are at the core of the current state and the problem. The problem definition should also include an assessment of the causal relationships between key components of the policy system. The goal should be to draw the strongest assessments we can from the available data (Layzer, 2002). Finally, the problem definition should include a set of beliefs about how the system ought to work and an assessment of nature of changed behavior desired (McDonnell & Elmore, 1987).

4.3.1. Current State: Business as usual means increasing miles of travel and converting increasing amounts of open space for development

Since the dawn of the automobile age, VMT in the United States has steadily increased. In 1940, people drove an average of 2,300 VMT per person (Federal Highway Administration, 2010). By 1980, the annual average was up to 6,700 VMT per person, and by 2008 the average had soared to 9,800 miles per person (Federal Highway Administration, 2010). Because population has been growing over this time period as well, total VMT has grown even faster than VMT per person. By 2010, Americans were

driving a total of 2.97 trillion miles in a year (Federal Highway Administration, 2010). Vermont's statewide average is higher than the national average, with 11,680 VMT per person, probably because so much of the state is rural (Sears & Glitman, 2010). By contrast, Chittenden County, the most urbanized part of the state, is slightly below the national average, at 9,855 VMT per person (Sears & Glitman, 2010).

There are significant financial, environmental, and social costs associated with all of that driving. On average, American households devote 16% of their total annual expenditures to transportation, more than they spend on food, clothing, healthcare, or entertainment (Bureau of Labor Statistics, 2009). The transportation sector was responsible for 28% of green house gas emissions in the United States in the year 2008 (US Dept. of Energy, 2010). It was also responsible for 73% of carbon monoxide emissions, 58% of nitrogen oxide emissions, and 38% of volatile organic compounds emissions (US Dept. of Energy, 2010). Similarly, the transportation sector was responsible for 29% of energy use in the United States in the year 2008 (US Dept. of Energy, 2010). Most of the energy used for transportation is petroleum-based (93.8% in 2009, 2.5% natural gas, 3.4% renewable, 0.3% electricity) (US Dept. of Energy, 2010). The fossil fuels that power our transportation system are a limited resource.

At the same time, Americans are also using an ever-growing proportion of the country's open space for residential and commercial purposes. At both the national level and in Vermont, open land is being converted to residential or commercial uses at a rate twice as fast as the rate of population growth. At the national level, in 1982 3.8% of the land area in the United States was developed. By 2003 that figure had climbed to 5.6%,

almost a 50% increase. During the same time period, population only increased by 25%. In Vermont, during the same time period, there was a 19% increase in population and a 40% increase in developed land (US Census Bureau, 2011).

4.3.2. Causal Statements: The connection between land use and transportation

It is generally accepted that the built environment is one of the determinants of how much people drive (Brownstone & Golob, 2009). Residents of a densely populated urban area, with sidewalks on both sides of every street, grocery stores every few blocks and dozens of destinations within an easy 10 or 15 minute walk, will drive far less than residents of leafy suburbs, whose streets tend to be long, winding, and disconnected, who must travel a few miles to the nearest store, and farther than that to significant employment centers. The attributes described in this simplistic dichotomy -- density, diversity of land use, design of streets and neighborhoods, and destination accessibility, along with distance to transit -- are the focus of most research on the connection between the built environment and travel measures such as VMT (Ewing, et al., 2007; Transportation Research Board, 2009). However, there is significant dispute about the size of that effect, and what other variables may mediate it, or may even be more important than it.

One of the earliest studies of the connection between the built environment and travel outcomes found significant inverse effects between density and VMT (Newman & Kenworthy, 1999). However, that early simple conclusion has been criticized on several grounds, including the fact that it involved highly aggregate data, which indicated correlations between density and VMT on a city-by-city basis, but said nothing about the

behaviors of individuals within those cities, or even about the patterns neighborhood-by-neighborhood (Brownstone & Golob, 2009).

Recently researchers have attempted to further clarify this analysis. Results are typically reported in terms of elasticity of travel behavior in settings with different built environment characteristics. For example, one recent study found that the direct elasticity between population density and VMT per capita is -0.6, meaning that a 10% increase in population is associated with a 6% decrease in VMT per capita (Cervero & Murakami, 2010). However, that relatively strong direct effect was partially offset by positive indirect effects. For example, areas with higher population density also tend to have higher road density, and higher road density is correlated with higher VMT/capita (Cervero & Murakami, 2010). A similar positive indirect effect was found for the higher retail accessibility and greater urbanized area sizes of more densely populated areas (Cervero & Murakami, 2010). Taking the direct and indirect effects into account, the net effect of a 10% increase in population density is only a 3.8% decrease in VMT per capita (Cervero & Murakami, 2010).

Other studies have found smaller effects. A meta-analysis of the data from 50 studies found that VMT was most sensitive to distance to downtown (also called destination accessibility), with a weighted average elasticity of -0.22, and job accessibility by automobile, with a weighted average elasticity of -0.2 (Ewing & Cervero, 2010). Surprisingly, given the results of earlier work, these researchers found little sensitivity of travel behavior -- not just VMT, but also walking trips and transit use - to density. The range of elasticities of VMT to density across the underlying studies

was -1.05 to +0.03, and the weighted average elasticity was -0.04 (Ewing & Cervero, 2010).

Despite the work that has been done to clarify how to measure the various aspects of the built environment that are expected to affect VMT, studies still have widely varying results. Part of the problem is that overall effects are small, and other factors, such as household income and employment status may dwarf the effect of the built environment on travel behavior. Although it is possible to control for these variables, a lot of detail is lost in the process of controlling, and significant distortions may thus affect the results. Some researchers have found that attitudinal and lifestyle variables are more important than built environment characteristics (Bagley & Mokhtarian, 2002). Another significant problem is the limitations of the available data, particularly longitudinal data that could clarify the difference between correlation and causation. Finally, there is the inherent difficulty of determining causation as opposed to mere correlation in any complex system. Nonetheless, it seems clear that the built environment plays a role in affecting how much people drive; from that, we can conclude that changing the built environment will likely lead to changes in how much driving people do.

4.3.3. Examples from other regions

Urban Growth Boundaries have been implemented in different forms and using different mechanisms across the US. Portland, Oregon has one of the longest-standing UGBs in the nation, implemented in 1979 in response to a statewide directive. The Portland UGB encompasses 232,000 acres (362 square miles) and 1.3 million people, and it consist of 4 key components: (1) a requirement that new development inside the

growth boundary be contiguous with existing development; (2) a requirement that public facilities necessary to support increased population are in place before any new development is initiated; (3) an expedited permitting procedure inside the UGB; and (4) the opportunity for local governments to zone for exclusively farm and/or forest land use regions, or large minimum lot sizes for rural residential areas, outside the UGB (Jun, 2004). The Portland UGB is generally viewed as the most successful UGB in the country (Carruthers, 2002). A strong regional governing body, combined with statewide coordination, are important reasons for its success (Troy, forthcoming 2011).

A different approach has been adopted for the UGB in the Denver region. There, the focus has been on voluntary compliance and financial and other incentives for shaping development. The Mile High Compact commits those local governments that sign on to developing comprehensive land use plans in accord with the principles of a regional vision statement known as Metro Vision 2020, and to using their comprehensive plans as the primary tool for growth and development decisions, but it shies away from dictating what the content of the plans should be. The key implementation techniques are an emphasis on transit-oriented development, with the incentive of increased sales tax revenue in those areas, and a boost in transportation funding for those regions that conform to Metro Vision 2020 (Margerum, 2005).

Maryland provides a third model of how these goals can be effectuated. Maryland enacted a state-wide law, the Smart Growth and Neighborhood Conversation Act, in 1997. Under this law, the state will not subsidize new roads, sewers, or schools that are not within state-identified “smart-growth” areas. The state also encourages in-fill

and brown-field redevelopment in smart-growth areas with tax incentives (M. H. Cooper, 2004).

Nationwide, there are at least 127 UGBs or similar growth management plans in place (A. Nelson, et al., 2007). However, the great majority of these only encourage compact development inside the UGB, but do not restrict growth outside the UGB, and in many instances the encouragement is quite weak. Some succeed in limiting leap-frog development, or protecting open space, but fail to encourage the kind of compact development that facilitates transit use (A. Nelson, et al., 2007). Others pay lip service to the concept of compact development without having sufficient incentives or restrictions to result in observable changes to existing land use patterns. Oregon's strong plan, with a powerful regional governing body and a goal of accommodating orderly growth across a large land area, remains one of a kind (Troy, forthcoming 2011).

4.3.4. Desired Outcome: What do we want to achieve?

Traditionally, the quality and function of our transportation system has been evaluated using various measures of mobility, or movement, such as vehicle trips, traffic speed, roadway level of services, and vehicle miles traveled. However, what we really value as a society should be not mobility per se, but accessibility: the ability to reach desired goods, services, and activities (Handy, 2005). The system ought to work so that we focus on maximizing accessibility, rather than maximizing travel for travel's sake. In fact, the desired outcome should be to maintain or improve accessibility while reducing mobility, because of the financial, environmental, and social costs of excessive travel, as described above.

At some point in the future, the state, the region, or individual cities may set targets for VMT reduction as part of achieving overall GHG reduction targets or to reach other pollution-related goals. For the present, the goal should be to stem the growth of VMT, moving towards a decrease in VMT per capita, without sacrificing access to desired good, services, and activities.²

4.4. Policy Formulation

4.4.1. Key actors: Towns and NGOs must instigate and implement policy change

Government decision-makers formulate and implement policy. Non-governmental actors, including advocacy organizations, experts, and the media, can also have significant influence in shaping the context in which government decisions are made (Layzer, 2002). In analyzing the potential for implementing an urban growth boundary in Vermont, we need to consider which governmental actors are likely to be involved, and in what capacities. We also need to consider which non-institutional actors will be involved, and what roles they would be expected to play.

The federal government generally has no authority to intervene in local land use decisions, and would have no basis for imposing or requiring a UGB in Vermont or anywhere else in the country. The only scenario under which the federal government might become involved in such a local matter would be if Chittenden County's air quality degraded to the point where it was no longer in compliance with the National Ambient Air Quality Standards ("NAAQS") for carbon monoxide, nitrogen dioxide, sulfur

² In some areas, where congestion is a greater problem, a focus on Vehicle Hours of Travel might be worthwhile. However, Vermont is relatively sparsely settled, so VHT is not a concern in this particular endeavor.

dioxide, particulate matter, or ozone. However, the federal government has not intervened in land use on this basis in the past (Bengston, et al., 2004), and is unlikely to do so in Vermont, where the problems are generally less severe than in other parts of the country (U.S. Env. Prot. Agency, 2011).

In Vermont, as in most other parts of this country, the state has delegated most of its authority over land use to municipalities (Fischel, 1985). Vermont gives the state more control over land use than many other states do, through its Land Use and Development Act, commonly known as Act 250 (10 Vt. Stat. Ann. sec. 6001 et seq.). Under Act 250, all proposals for development projects that exceed ten acres or ten residential units, as well as certain smaller projects, are reviewed by the state for compliance with the statutory criteria, which include protecting the state's water supply and other natural resources, limiting air and water pollution, not overburdening municipal and educational systems, and not causing unreasonably dangerous or congested conditions on the state's highways (10 Vt. Stat. Ann. sec. 6001 et seq.). However, Act 250 is not a statewide zoning plan.³ As it stands, several studies have concluded that Act 250 has not succeeded in preserving farmland or curbing sprawl (Anthony, 2004)

When other states have taken action to require UGBs or other growth management mechanisms, it has typically been in response to rapid, uncontrolled growth. Act 250 was implemented in response to just such concerns, after the completion of the two interstates (Gilles, 2010), but in recent years growth in Vermont has been slower than the national average, and slower than historic rates over the last 50 years (US Census

³ The original plan for Act 250 was that a statewide zoning plan would follow, but this aspect of the legislation was never enacted (Gilles, 2010).

Bureau, 2011). The reality of relatively slow growth makes state instigation of a UGB unlikely in the foreseeable future.

It is also unlikely that county government will be a key actor. Vermont has a very weak and limited county governance system. The primary county functions are judicial, law-enforcement, and elections and record-keeping related. With no land use function or officials in place, the county would not be a key institutional actor in this issue (Vermont States, Title 24, Chapter 5, County Officers, Powers and Duties).

Chittenden County has two county-wide bodies that are responsible for aspects of transportation and planning, and they may be key actors in an UGB, but as they are currently constituted neither one has sufficient power to implement a UGB. The Chittenden County Metropolitan Planning Organization's role is to "coordinate and prioritize transportation projects to be implemented with Federal and/or State assistance." Every town within Chittenden County participates in the planning process, as does the state agency of transportation and other interested agencies. (Chittenden County Metropolitan Planning Organization, 2007; Weiner, 1992). The CCMPO brings together many of the entities that should be most involved in developing a UGB, but as an institution it lacks the power or authority to act. Similarly, the Chittenden County Regional Planning Commission's stated purpose is "to promote the mutual cooperation of its 19 member municipalities and to facilitate the appropriate development and preservation of the physical and human resources in Chittenden County" (Chittenden County Regional Planning Commission, 2011). However, the RPC's role is generally

limited to providing planning assistance, and not implementing land use restrictions or plans.⁴

In Vermont, as in most of the United States, towns have primary authority over zoning and land use decisions (Fischel, 1985). Towns are thus the most important key actors, and it is likely from towns that any new policy will emanate. Each town in Chittenden County has a slightly different government structure. Some, like Burlington, are headed by a mayor and city council (City of Burlington, 2011); others like Charlotte by a town clerk and a selectboard (Town of Charlotte, 2011). Each town has a zoning or planning board. Those entities would all be likely to be involved in any action of this nature.

Non-institutional actors will also play an important part of developing and implementing a UGB for Chittenden County. These non-institutional actors would likely include non-government organizations with an interest in land use, transportation, or both, such as Smart Growth Vermont, which promotes compact development, or Local Motion, which focuses on non-motorized transportation and recreation. They would also include leaders from large and small local businesses, including real estate and construction companies that would be affected by a UGB, as well as major employers. All of these entities would have an important role to play in promoting (or objecting to) a UGB, providing input on the anticipated effects of a UGB, and fleshing out the details of how and where the UGB should be implemented.

⁴ The CCMPO and the CCRPC are in the process of merging into a single organization, effective July 1, 2011. After the merger they will retain the same powers and limitations as described in the text, under a single umbrella (CCMPO, 2011)

4.4.2. Governance structure: A new regional entity

To work as intended, a UGB would require the creation of a new, regional-level entity to develop boundaries, design restrictions, develop incentives, and ensure coordination among the many local entities that would be involved and affected. In other words, it would have to be system-changing (McDonnell & Elmore, 1987). Without an overarching new entity, individual jurisdictions could change their zoning to try to create the same effect, but such an effort would most likely backfire. If some towns restrict growth in an effort to re-direct the growth to the urban core, without a unified regional approach, those individual town efforts would most likely serve only to shift growth to other towns, perhaps even to more sprawling, farther-flung locations (Byun & Esparza, 2005). A successful UGB requires a unified, regional approach to avoid this sideways shifting that serves no purpose. Moreover, the UGB needs to encompass a region that is large enough to avoid shifting development to just outside the outer circle, or it will make for even longer commutes than would exist without the limits on development in the “doughnut” region. Byun and Esparza describe this as a “spillover” effect – where political fragmentation among local jurisdictions leads to the enactment of piecemeal land use restrictions that shift growth to distant but uncontrolled localities (Byun & Esparza, 2005).

In this regard, the first question to consider is how large the UGB needs to be to be effective: both the inner circle, where growth is permitted and encouraged, and the outer circle, where it’s proscribed or limited. A key concept for determining the outer bound of the UGB is the “commuter-shed”: the area from which the workforce of the

urban center of Chittenden County is drawn. As of the 2000 census, 79% of the Chittenden County workforce lived within the county. Another 19% lived in the five Vermont counties that share a border with Chittenden County (US Census Bureau, 2003). Only 1.5% live outside the state, and many of these do not commute into work on a daily basis (US Census Bureau, 2003). Just as an estuary restoration activity must encompass the entire watershed to be effective, a UGB must encompass all (or at least a significant proportion) of the commuter-shed, or it will not succeed in reducing VMT.

The fact that such a small proportion of commuters come from outside the state makes this undertaking easier to coordinate than it would be otherwise. The effectiveness of Portland, Oregon's UGB has been undermined by the proximity of Clark County, Washington, which has received a significant proportion of new development that might have been located in Oregon were it not for the UGB (Jun, 2004).

The new regional-level entity could take many forms. One possibility would be a union municipal district between the towns in the commuter-shed. Such a union could be created via the mechanism set forth in the Vermont Statutes for intermunicipal contracts and development, 24 Vermont Statutes Chapter 122. In this scenario, the towns would start by reaching an agreement on the purpose of the union and the precise organization, composition, and nature of the new entity, including what powers and duties would be delegated to it. Once the towns reached agreement at that first stage, each town would then develop a new zoning plan in accord with the general outlines of the UGB, and take the plan, along with the intermunicipal contract, to its own electorate for approval. The

towns would agree in advance on what to do if fewer than all the towns agreed to participate or voted in favor of the final plan.

The union municipal district mechanism has been used in Vermont on a smaller scale, for intermunicipal agreements on issues like shared sewer service or shared employees between towns (Salkin, 2005). It has never been used to develop an agreement between so many towns or for such broad purposes. However, in function the union municipal district would be similar to the Mile High Compact used to manage land use and growth around Denver, Colorado. The Compact was adopted by 30 cities and counties upon its inception in 2000, and as of December 2010 it had 46 signatories that represented 90% of the region's population (Denver Reg. Council of Govs., 2010). Each signatory agreed to develop or amend comprehensive land use plans in accord with the principals of Metro Vision 2020, the regional planning documents, as well as agreeing to adopt urban growth boundaries as established by Metro Vision 2020 (Denver Reg. Council of Govs., 2000).

A second possibility for a new regional-level entity is a network. A network is a forum in which numerous interdependent entities with splintered power can come together to develop joint solutions to shared problems (Salamon, 2002). Networks can bring together entities that would typically be separated by some artificial barrier, like the towns and the other key actors who might be interested in implementing or affecting the development of a UGB in Vermont. The network structure gives these entities a space for working together, across those barriers, to develop and implement solutions to shared

problems (Lubell, Schneider, Scholz, & Mete, 2002; Schneider, Scholz, Lubell, & Mindrute, 2003).

While such networks can arise organically, the existence and effectiveness of such networks is greatly enhanced by support from higher levels of government (Schneider, et al., 2003). Although, as already noted, federal, state, and county governments are unlikely to be key players in this effort, they might be willing to sponsor an effort if they were encouraged to do so by residents and officials of the local region. If the state or federal government could be convinced to support the establishment of a regional network to address land use, it would make a significant difference.

The value of upper-level support for network development was demonstrated in a study of watershed networks. More than 20 years ago, Congress enacted a program to improve water quality in degraded estuaries. The program provided monetary resources for staff and research; a forum for deliberation and negotiations that included government representatives, experts, and local business leaders, interest groups, and other stakeholders; and, perhaps most significantly, “a newly defined policy and geographic boundary that encouraged contact between organizations dealing with interrelated, acute, unresolved policy problems” (Schneider, et al., 2003). The federal support for these networks was critical to their success. Networks in regions that qualified for this support spanned more levels of government, included more experts in the negotiations, and fostered stronger interpersonal ties between diverse stakeholders than those that did not receive such support, thus enhancing the likelihood of successful resolution of contentious issues (Schneider, et al., 2003).

Support from the federal or state level would be equally valuable for a UGB. For example, state law in Maryland provides financial incentives for towns to develop inter-jurisdictional agreements that improve planning and efficiency (Salkin, 2005). Such support might not be absolutely necessary, but it would certainly enhance the likelihood of success of such an effort. Also, state review of local plans can increase the likelihood that the local plans will be in accord with the overarching state vision (Anthony, 2004; Carruthers, 2002).

Although the Denver example shows that a union municipal district approach is possible, it also demonstrates the shortcomings of this approach. In order to get multiple jurisdictions to sign on to a binding agreement, the terms of the agreement tend to be watered down, often to the point where they are ineffectual. Also, because the compact is limited to governmental entities, not everyone with a stake in the matter is at the table. This increases the possibility of failure as a result of challenges by those who are not included in the process.

The network approach, which typically operates on a consensual basis, usually lacks significant enforcement power. While this sounds like a weakness of the approach, it may lead to greater acceptance by the existing organizations, primarily towns, that would be asked to cede power to the new regime. Most organizations are hesitant to yield power to new institutions (Wheeler, 2002). Moreover, there are particular challenges with new regional institutions. Residents of the suburban, exurban, or rural areas may not perceive the ties they have to the city, and to the vitality of the city, and thus may be particularly reluctant to cede any authority to a new institution that may be

dominated by the more larger city (Wheeler, 2002). The network setting would give those stakeholders the opportunity to watch and wait, signing on once they could see the benefit to their communities. This approach might take longer, but it would be more likely to succeed in the end.

With either format, a key component would be public engagement and education – about the negative impacts of excessive travel, including the environmental, economic, and social justice implications of continuing the business-as-usual approach. In any event, the final contours of the new institution will have to balance the need to guide the county in this new direction against the reality of not succeeding without the support of all of the affected towns.

4.5. Policy Implementation: Moving from concept to action

Another key issue to consider is “policy legitimization.” (Brinkerhoff & Crosby, 2001). This refers to finding someone who will champion the new policy, and who will provide the kind of supporting information necessary to move the proposed policy forward (Brinkerhoff & Crosby, 2001). There needs to be someone pressing for a land use solution to the pollution problem for a UGB to move forward. That person could be a state leader, such as the Governor. It could be a leader of one of the NGOs mentioned above as potential key non-institutional actors. It could be the mayor of Burlington or one of the other towns adversely affected by excess automobile travel and pollution. Without a strong policy champion, one who can convince the public of the merits of a land use solution to a transportation problem, a UGB is unlikely to succeed.

In Oregon, the original policy champions were people who wanted to protect farm lands from development. The state planning laws that were enacted in 1973, and the Portland UGB as adopted in 1976, were not intended to change the nature of growth within the UGB, but rather to protect the lands outside the boundary (Calthorpe & Fulton, 2001). Two decades later a nonprofit environmental advocacy group began to push for changes in the land use patterns inside the UGB. Their initial goal was to prevent the construction of a major highway project that would have facilitated access to the lands outside the UGB, and thus created development pressures in the protected areas (Calthorpe & Fulton, 2001). Rather than simply opposing the highway they countered with an alternative vision of the region's future, one that included a new public transit system and compact, mixed-use development near the transit stops. To explain and quantify their vision, they promoted research into demographic trends, housing and job markets, and land capacity. They developed new measures of accessibility and walkability to quantify the benefits their vision offered (Calthorpe & Fulton, 2001). Without their leadership, Portland's UGB would still exist, but it would not promote compact growth, would be subject to on-going pressure to expand into the space currently designated as farm-land or open space, and would not contribute to reducing VMT, vehicle trips, or transportation-related air pollution.

Another important step is "constituency building:" identifying the "winners" or those who would be expected to benefit most from the new policy into the process, and convincing them to take an active role in promoting the policy (Brinkerhoff & Crosby, 2001). Winners (and losers) can be counted among the affected towns, institutions, or

individuals in the area. Inside the growth boundary, the potential benefits for winners would be growth opportunities, increased tax revenues, additional support for schools and other local institutions. The downsides, which might hold sway with some, would include concerns about overcrowding, congestion, decreased property values, and perhaps decreased quality of life. Some potential benefits for towns in the zone where development is restricted include preserving the traditional character of the outlying towns, enjoying the benefits of open space, supporting agriculture, which needs a critical mass to have support systems like implement dealers, wholesale milk dealers, etc., and reduced pollution, emissions, and resource consumption. For those in this zone, the question is whether these benefits are sufficient to outweigh the costs of foregone development opportunities, and whether the towns and landowners outside the boundary can be persuaded to support the plan.

Land use regulation, even if it significantly restricts the use or development potential of land, is generally not a government “takings” for which compensation is required (Fischel, 1985). Usually, compensation is required only if the restriction is so severe that no reasonable use of the land remains. However, if enough land owners believe they have been or will be harmed by a UGB, they may take action to prevent it, rescind it, or force the government to provide some kind of compensation.

In Loudon County, Virginia, for example, shortly after the county’s Board of Supervisors enacted a new policy that imposed strict limits on new residential developments in the rural parts of the county, the proponents of the growth limits were

voted out of office, and the rules restricting new development were quickly repealed (M. Cooper, 2004).

Voters in Oregon passed a ballot measure in 2004 that allowed any land owner who lost the right to develop land as a result of the UGB legislation to make a claim against the state for the lost value. If the state would not pay the claim, it could not enforce the land use restriction (Troy, forthcoming 2011). As of 2007, there were close to 7,500 claims for a total of \$19.8 billion. That year, however, the ballot measure was modified to allow land owners outside the UGB to build a small number of homes on their property, if such development would have been permitted at the time the property was purchased (Troy, forthcoming 2011).

Public participation is an essential tool for legitimacy and constituency building, and for avoiding the kind of backlash experienced in Loudon County and Oregon. Bringing the public into the process of developing and implementing a UGB offers many potential benefits, including incorporate public values into the process, improving quality of final decisions, resolving conflict between competing interests, building trust in institutions, and educating the public (Beierle & Cayford, 2002). To reap these benefits the public's role must be both substantive and substantial. For example, the public should be involved in determining the borders of the UGB, delineating what kind of building or development activities are to be permitted outside the UGB, considering the density and mixed uses that should be permitted in various places within the UGB, and more. Denver's Metro Vision 2020, for example, was developed by a 40-member task force, consisting of business leaders, interest group representatives, citizens, and elected

officials (Margerum, 2005). The Denver effort also utilized a 19-member steering committee. This group originally consisted only of elected officials, but in response to public outcry it was expanded to include private and non-profit representatives, giving it much greater legitimacy (Margerum, 2005).

If the public's role is limited to "consultation," a limited opportunity to comment on a predetermined policy, there will be no real benefit in terms of improving the quality of the policy. Such a course could undermine the entire effort, by turning public opinion against the process. A more robust opportunity for public input will require a significant investment of time and resources, and it may lead to an unexpected outcome, since the public would have the power to alter the agenda, but it is the best way to gain the benefits of public participation described above (Bickerstaff & Walker, 2001).

Resource accumulation is another critical aspect of policy implementation. Both people and funds need to be allocated to effectuate the new policy (Brinkerhoff & Crosby, 2001). Any new regional institution, whether based in intermunicipal contract or a network model, will require both funding and staff. The most likely source of funding is the participating towns, although a preferable source of funding would be the federal government (on the national estuaries program model, described above, see Schneider 2003) or the state government (as in Maryland, described above, see Salkin 2005). Financial support from the state or federal government would remove a significant obstacle to the success of the new regional institution. Towns would be far more likely to consider the UGB concept, and get involved in preliminary attempts to develop a UGB, if there were no immediate financial costs associated with participation.

Over the longer term, the primary need for funds would be to support staff and studies. If all zoning and planning responsibilities are moved from the towns to the regional level, there could be significant efficiency gains and costs savings, as redundant positions are eliminated. However, it is more likely that the towns will retain some authority over their planning and zoning functions, and therefore that they will continue to need staff and funding (Gale, 1992). The need for new money to support the new institution thus appears unavoidable.

Whether the transfer of authority over planning and zoning from the towns to the new regional institution is partial or complete, the reorganization of functions between existing structures and new structures will likely involve many of the same people. These people may shift from working at the town level into new regional roles. However, particularly if people are brought into the regional level on a part-time basis, and continue to work for the towns, there are likely to be issues of loyalty, which may affect decision-making. Local loyalty is just one of the constraints under which policy makers operate, and which might affect their effectiveness and the effectiveness of the new institution (McDonnell & Elmore, 1987). An important factor in the success of a regional body is whether the key members are appointed or elected. Elected officials tend to retain a more local focus, while appointed officials tend to take a broader view, likely because they are less concerned about catering to constituents on a short-term basis (Gerber & Gibson, 2009).

4.6. Policy Evaluation

The last piece in an implementation analysis is developing a system to monitor progress and impact. The evaluation must begin with clarity about the policy goal, and move from there to consider the program activities in terms of the goals and to define performance indicators. The relevant data and indicators can be grouped into the short term actions, or outputs of the new policy; the medium term outcomes of the new policy, and the long term impact of the policy (Nakamura & Smallwood, 1980). In this case, the policy goal is reducing VMT without sacrificing accessibility. As such, it is important to track not only travel measures, but also accessibility.

The long term consequences reflect the ultimate success or failure of the policy. In this case, the long term consequences include VMT and automobile trips, both of which should decrease. In terms of accessibility, more people should be living and/or working in proximity to the services they need to access on a regular basis, including their jobs, the stores they frequent, and the friends and family they want to visit. This may be reflected in an increase in walking or transit trips. Other measurable consequences should include air quality, which should improve, and fuel consumption in the region, which should decrease. Policy monitors should also track vehicle hours of travel: if they increase, especially if VMT holds steady or decreases, that would indicate the development of a congestion problem, which could undermine the beneficial effects of the UGB.

The built environment reacts slowly to changes in development laws, because only a small portion of the housing or commercial stock is built or replaced each year. It

is therefore important to develop shorter-term indicators to ensure that the system is on the right track even before the final impact in VMT or other travel and accessibility indicators is large enough to register. In this regard, the very first issue to evaluate would be the enactment of the UGB. Critical questions regarding enactment of the UGB include how many towns agree to participate, and whether sufficient authority is delegated from the participating towns to the new regional institution to make the UGB effective. Weak UGBs have been enacted around the country, and they have been shown to have little or no effect on development activities (A. Nelson, et al., 2007).

Once the UGB has been enacted, but still in the category of short term outputs, would be consideration of building permit activity: do decisions on permits inside and outside the growth boundary conform to the expectations set forth in the growth boundary legislation? Is the entity charged with reviewing permit applications (whether a new entity or a re-tooled existing entity) acting promptly and responding to permit applications and other issues in a timely and useful way? Are any loopholes developing that undermine the effectiveness of the UGB in directing development towards the core?

In many ways, it is the medium-term outcomes that would be most important. These indicators are key to maintaining support for the program for a long enough period of time for the long term benefits to begin to materialize. In terms of land use, the key data to monitor would relate to development: how much is being built inside the growth boundary, how much is being built outside the growth boundary, and (importantly) how much is being built beyond the reach of the growth boundary district? In terms of

transportation, the reductions in VMT per capita and in average trip length should begin to materialize within about 10 years.

4.7. Conclusion

Implementation of an UGB is an attempt to convert the intractable policy problem of reducing VMT to a more manageable, milder problem, one that sets easily enforceable rules rather than trying to change the behavior or preferences of major swaths of society. However, it is unlikely to occur without a new, regional institution, ideally in the form of a large network. Moreover, it will require the voluntary relinquishment of control over planning and zoning by the towns in the region. These are high hurdles to the success of any such proposal.

The critical piece for moving forward with such a plan is the identification of a policy champion, a local figure with authority who can present the idea to the public. The policy champion would be the one to make the case that VMT is an important problem and a UGB is a good solution, as well as fleshing out the rough contours of how to proceed. Persuading the state government to support the idea is as important as persuading the public, because official support, both financial and regulatory, will make a big difference in the success of such an effort.

However, if those hurdles were surmounted, and if sufficiently strong restrictions on growth were enacted in the areas outside the growth boundary, the result could be a decrease in vehicle travel on the order of 25% over a 40-year time horizon, without any loss of accessibility. Such a desirable outcome justifies further exploration of this concept by the officials who could make it happen.

4.8. References

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